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FOSSIL INSECTS.*

By T. D. A. Cockerell.

In these serious days, it seems just a little grotesque that I should cross half a continent to address you on a subject so remote from the current of human life as fossil insects. The limitations of our society do indeed forbid such topics as the causes of the war or the evil effects of intercollegiate athletics; but I might have chosen to discuss lice or mosquitoes—any of those insects whose activities have before now decided the fate of nations. My excuse for avoiding these more lively topics only aggravates the offense, for it is the fact that I have never given them adequate attention, but have in the past ten years occupied myself with matters having for the most part no obvious economic application.

There is, however, another point of view. Many years ago I had the good fortune to meet the eminent ornithologist, Elliott Coues, at Santa Fe. We spent a considerable part of the night discussing a variety of subjects, from spiritualism to rattlesnakes, and when we parted he made a remark which those who knew him will recognize as characteristic. He said, "Cockerell, I really believe that if it had not been for science, you would have been a dangerous crank!" Surely experience and history alike confirm the essential sagacity of the observation, as applied not merely to your lecturer, but to mankind in general. How often has our poor human race exhibited the qualities of a dangerous crank, owing to the lack of those which devotion to science may stimulate! Has it not been so

*Annual Address before the Entomological Society of America, delivered at New York, December 28th, 1916.

in Europe in these dreadful days? It is true that science is being accused as the handmaiden of war, is blamed for the many diabolical inventions for taking human life; but these things are aside from the great current of scientific thought, and it would be equally just to accuse language, which is at the very root of human progress, because forsooth it has been the vehicle of every hateful emotion.

The pursuit of science, by which we mean the effort to understand nature, is akin to religion, because it enables us to see the world as part of the universe and ourselves and our affairs as particular examples of universal phenomena. We do not thereby lose our self respect; on the contrary, it should be increased by the consciousness of having a part in the affairs of the cosmos. It is some such feeling as this, not usually defined in words, which keeps the naturalist to his task. People ask him, why do you labor over that microscopical animal, of no apparent interest to any one? They might as well ask a bricklayer why he thinks it worth while to lay any single brick of some mighty building.

The general sense, the pious belief, that every part of the scientific structure is worth while, has been greatly heightened in recent years by researches in genetics. It is a marvelous thing that we can reason from Mendel's peas to human life; that Jenning's protozoa should be significant for the study of sociology. Thus we come to the conviction that even a fossil cockroach from the coal mines of Pennsylvania has some story to tell which may serve us in our day. Entomologists are not as humble as they were in my young days, but I fear they do not yet appreciate the full significance of their science in relation to the philosophy of life. The enormous variety of insect life, exhibiting innumerable adaptations to all sorts of conditions, gives us unparalleled opportunities. What New York is to the sociologist, the class Insecta must be to the naturalist. A single species of insect, *Drosophila melanogaster*, has enabled Morgan and his associates to largely reconstruct our ideas concerning the mechanics of heredity; to give us well ascertained facts in place of much vague speculation.

It is, however, from the *comparative* morphology and physiology of insects that we may expect to learn most about the phenomena of evolution. I recall being present several years ago at a meeting at Boston, when Professor J. C. Bradley

exhibited a number of figures of hymenopterous wings, and offered some opinions concerning the evolution of the venation. In the discussion which followed, the criticism was made that all the species concerned were living ones, that obviously they could not be thought of as ancestral to one another, and consequently any attempt to see in them a true evolutionary series must be futile. This sounded reasonable, but it did not take into account the fact that while *species* may all be recent *genera* of insects are old, and of extremely different antiquity. This is one of the lessons we have learned from the study of fossil insects, and it teaches us that the existing insect fauna is extremely rich in ancient types, which do really illustrate evolutionary sequence. The reason for this is rather obvious. The stream of insect life branches in a complex manner and owing to the enormous diversity of possible adaptations, resulting from the diversity of physical conditions, of food and of enemies, very many of the products of evolution have been preserved without important modification. This is especially striking when we regard *characters* rather than *species*, and observe differences in the minute structure of the tegmina of Palæozoic cockroaches, corresponding with similar differences to be found in their living representatives. Just as the infinite variety of higher animal life has been built up from a scarcely altered fundamental series of *tissues*, so families, genera and species have arisen not so much from entirely new developments, as from the shuffling of ancient characteristics. There is, of course, no doubt that definite progressive evolution has taken place among the insects just as among the vertebrates; thus the greatly modified. mouth-parts of bees and butterflies, adapted for sucking the nectar of flowers, certainly came into existence after the Palæozoic, and when plants with suitable corollas had developed or were developing.

There is no doubt that the Mesozoic, the period of the rise of the higher plants, saw a remarkable development of insect life, concerning which we know too little, owing to the relative scarcity of fossils. It does not appear, however, that there is much if any innate tendency to progress, without reference to changing conditions. During the Tertiary epoch there seems to have been little forward evolution, and in the north temperate regions we may detect a very perceptible contraction and impoverishment of the fauna since the Miocene. In the absence

of a progressive movement, there has nevertheless been much of the shuffling already mentioned, producing a great mass of specific forms, while many genera have become extinct. Aside from these general questions, we may value the evidence afforded by fossil insects for the light thrown on geology and paleogeography. In the first place, although the *genera* of insects are of long duration, the *species* appear to be short lived. The best evidence for this opinion comes from the fact that strata supposed by the geologist to be of nearly or quite the same age, often contain insect-faunulæ in which the species are all distinct. This may be partly due to different ecological conditions and to migrations, but it certainly is due in part to the comparatively rapid evolution of insect species. This is especially proved by the Pleistocene beetles studied by Scudder, which are closely allied to modern species, yet distinct. Professor Wickham is now engaged in the study of many additional Pleistocene beetles, and though his work is not finished, he kindly informs me that "they seem to be pretty nearly all different, subspecifically at least, from those of today."

Owing to the complexity of insect life and the facilities these animals have for getting about, faunæ are constantly in a state of flux, species locally dying out, and others coming in. Thus there can be little doubt that complete collections made in any locality at intervals of one hundred years would be appreciably different; except perhaps in the tropics, where conditions are likely to be more uniform. It is doubtless on account of this fact that we not rarely find non-functional examples of "mimicry," which are offered as obstacles to the view that mimicry has any adaptive significance. It is evident that the almost kaleidoscopic insect fauna must present characteristics which are to be understood in relation to the past rather than to the present. It results from all these considerations that fossil insects, when they can be obtained in any numbers and from different levels, afford a very delicate index to the details of stratigraphy, probably surpassing in this respect every group of organisms except mammals, which are not available for the purpose until we reach the Tertiary. The obvious objection to the use of insects in this manner arises from their comparative scarcity; but this has been exaggerated, and every year brings to light new localities. In particular, the Pennsylvanian (Upper Palæozoic) coal bearing strata of Maryland, Pennsyl-

vania and West Virginia have lately been found by Mr. H. Bassler to contain numerous faunulæ, mostly cockroaches, which I have been permitted to study. Scudder and Handlirsch had already observed that practically every Palæozoic locality yielded different species, and I have also found this to be the case. Considering the number of species and localities discovered by Mr. Bassler in a couple of years or so, we may reasonably expect eventually to have a very good detailed knowledge of the insects of the Pennsylvanian, and thereby have the means of elaborating a very accurate stratigraphy of the anthracite coal region. The tendency of all these studies is to enlarge our conception of the duration of the Pennsylvanian, which must represent an enormous amount of time. The main outstanding question now is, can we not only distinguish all these cockroach faunulæ—as we certainly can—but also place them, from the evidence afforded by the insects alone, in the right order? In other words, can we recognize a direct forward evolution, or are we again confronted by a shuffling process? Before attempting to answer this, we must get rid of the idea that regular progressive development necessarily occurred, and only waits to be detected. In the Tertiary, were it possible to restore the faunæ of a million years ago to life, and place them beside those existing now, there are certainly several groups, at least, in which no entomologist could distinctly affirm which was the more primitive. The best he could do would be to point out that whereas both lots contained archaic genera, there were rather more of these in the older series; and to do this he would need very complete materials.

Returning now to the Palæozoic fauna we find, as Handlirsch has pointed out in several papers, that insect life begins, so far as we know it, with that remarkable group called Palæodictyoptera. The so-called Silurian insects are clearly valueless, and the exact age of the oldest Palæodictyoptera is still a matter of dispute; Mr. G. F. Matthew still adheres to the opinion that the remains from St. John, New Brunswick, are of Devonian age. He points out that cockroaches are entirely absent, that Devonian genera exist among the accompanying plants, and that a later (Mississippian) facies is due to the fact that the deposits represent an old delta plain, whereas other known Devonian plants are from what was hilly country or sea-coast. On the other hand Kidston and David White,

judging from the plants, would refer the beds to the Carboniferous, even later than the Mississippian. Leaving these matters undecided, there are still some important facts which admit of no dispute. In the first place, the insects, like the higher flowering plants, first appear on the scene in a highly developed condition. It is true that the Palæodictyoptera are very primitive as compared with our modern Lepidoptera, Hymenoptera or Coleoptera, but in their own particular line, they represented a wonderful development of insect life.* There was evidently great variety of form and structure, while many of the species reached an enormous size. The anterior wings of *Archæoptilus gaullei* Meunier are estimated to be 18 cm. long, and as the distance between the wings is 24 mm., the total expanse is 384 mm.—over 15 inches.† Truly, there were giants in those days! This exuberant type flourished during a period *before the rise of the Blattids*, but extended into the Pennsylvanian, where, as at Mazon Creek, Illinois, it is accompanied by a rich fauna of Protorthoptera and Blattoids. It existed equally in Europe and North America, and in both areas gradually disappeared during the Upper Carboniferous or Pennsylvanian. The disappearance of the Palæodictyoptera is coincident with the rise of the Blattoids; and in America, at least, we soon come to a period when the Blattoids were dominant, to the total exclusion of Palæodictyoptera, and the great reduction of all other insects. This lasts to the end of the Pennsylvanian, and perhaps into the Permian; but in the Permian strata of Kansas, in which Sellards obtained a very rich insect fauna, Blattoids are in the minority, and other insects are numerous. Thus we have certainly three great periods, so far as the insects are concerned; one prior to the appearance of Blattoids, one during which the Blattoids and Palæodictyoptera and Protorthoptera existed together, and one during which the Blattoids were dominant almost to the

*Reconstructions of these insects must not be taken too seriously. In his very valuable and suggestive paper on the Ancestry of Insects (Am. Jn. Sci., Nov., 1916), Mr. J. D. Tothill copies a couple of figures from Handlirsch, which that author states to be diagrammatic reconstructions. Mr. Tothill, however, makes Handlirsch's hypothetical and reconstructed Palæodictyopteran larva a *Stenodictya*, and proceeds to discuss the larva of that genus, as if it were well known.

†The largest known insect, *Meganeura monyi* Brongniart, from the Upper Carboniferous of Commentary, France, is stated to have had an expanse of fully 70 cm., or about 2 ft. 4 inches. Handlirsch refers it to the Protodonata, a type prophetic of our modern dragon-flies.

exclusion of other types. If we go into the Permian, we have still another great period, in which the insects were smaller, and becoming more diversified, with the Blattoids in the minority.

This does not by any means exhaust our catalogue of sequences. Scudder in 1896 gave an elaborate table showing that during Upper Carboniferous and Permian time there was a fairly regular decrease in the size of cockroaches, so that if one had a number of faunulæ, the average size of the members would be an index to the relative ages of the strata. Since Scudder's time some of the opinions of geologists have changed, and from the recent material which has come in, I do not believe that this class of evidence is as valuable as it seemed to be; yet it is probably not without significance. More important in some respects is probably the relationship between the Archimylacrid and Mylacrid Blattoids, two groups easily distinguished as a rule by characters of the venation. The Archimylacrids appear to be the older, and these, along with the Palæodictyoptera, abound both in Europe and America. The Mylacrids, on the other hand, are essentially American, and appear to have developed during a period when there was no land connection between the Old and New Worlds. The proportion of Mylacrids in a given fauna is probably highly significant for stratigraphy; and the whole group emphasizes the fact already suggested by other evidence, such as that obtained by Petrunkevitch from a study of the Arachnids, that during middle Pennsylvanian time, at least, the evolution of the American fauna was wholly independent of that of Europe. Thus, as we investigate these matters, we do seem to observe a distinct procession of events, which cannot be without significance for geology or evolution.

The Permian, or closing period of the Palæozoic, was marked in North America by an elevation of the land surface and a general reduction of temperature. This continued into the Mesozoic. The new conditions appear to have been unfavorable to Blattoids, and to have given opportunity for the development of diverse types of smaller insects, many of which passed their early life in fresh water. There was at the same time a remarkable development of terrestrial cold-blooded vertebrates. The new start thus made probably may be taken as representing the foundation of the modern insect-fauna, though several impor-

tant orders did not appear until much later. The appearance of the Coleoptera very early in the Mesozoic, with perfectly characteristic elytra having sometimes quite modern-looking color-patterns, is surprising and not at present to be explained. The Diptera, Lepidoptera and Hymenoptera all came in later. The Upper Mesozoic or Cretaceous strata have as yet proved extremely poor in insect remains; less than fifty species are known, and most of these are quite worthless objects. This is very unfortunate, as it is probable that during this period most of the modern families of insects had their origin. Nothing would do more to throw light on the relationships of living insects than the discovery of a rich Cretaceous fauna. It is surprising that among the numerous Cretaceous plants, for example in the Laramie of Colorado, where the preservation is so good that it is sometimes possible to peel off the epidermis of leaves, insects hardly ever occur. A Blattoid (*Stantoniella*) was indeed found in the Judith River beds of Montana, but it remains unique. An astonishing find was that of an apparent Fulgorid (*Petropteron*) in the Pierre Cretaceous, a marine formation, at Boulder, Colorado. It had fallen into the sea, and been buried in the mud of the littoral zone. The most hopeful discovery, so far, is that of a very good Trichopteron (*Dolophilus*, a genus still living) in Upper Cretaceous amber in Tennessee. If an insect fauna can be found in this amber it will be of extraordinary interest and value.

Attention should be called to a very interesting paper by Mr. R. J. Tillyard, published this year by the Queensland Geological Survey. He describes a number of Australian fossil insects, and in particular a supposed Lepidopteron,. *Dunstania pulchra*, from the Trias, said to be the oldest Lepidopteron known. This has since been discussed by Meyrick, who concludes that it may be Homopterous, but cannot be Lepidopterous. As he remarks, the thickened wing-margin is unlike that of Lepidoptera. There is certainly a suggestion of a Cicada-like form in the region of the cubitus.

The Tertiary epoch represents perhaps four million years, certainly much less than half the Mesozoic. At the close of the Mesozoic there was an uplift similar to that marking the Permian, and during Tertiary time this has been maintained, with minor oscillations, while the continental climates in north temperate regions have become colder and more arid. Thus

in Colorado the end of the Cretaceous marks the emergence of the country east of the mountains from the sea, and the transitional marsh conditions, with an abundance of luxuriant vegetation, produced the deposits now yielding the Laramie coal. About this time the great dinosaurs died out, and the higher mammals began to show what they could do. The story of Tertiary mammalian life is a wonderful one, and our knowledge of the details is now very considerable. Reasoning from analogy, we might expect that the Tertiary would show a progressive movement in insect evolution comparable with that marking the end of the Palæozoic and beginning of the Mesozoic. It is a fact that on comparing the Tertiary insects with the Mesozoic, there are differences in part resembling those observed among the mammals. The Tertiary insect fauna is essentially modern, indeed it may be said that we have it still with us. It is far richer and more varied than that of the Mesozoic, especially in such groups as Lepidoptera and Hymenoptera. In the flora, we have a remarkable expansion and development of the herbaceous type, but no radical modification comparable with the origin of the higher flowering plants. So also among the insects, we have a great increase in variety, an immense series of adaptive modifications, but nothing to be compared with the origin of the Coleoptera, Diptera, Lepidoptera and Hymenoptera. Has nature partly exhausted her possibilities, new adaptations being limited owing to the very success of the older ones?

As students of particular groups of insects, we are keenly interested in the evolution of the modern families and genera. As we look at the known Tertiary forms, we are impressed by the number of genera identical with or closely related to those now living, and the extreme scarcity of extinct families, or even subfamilies. There is this to be said, however, that the oldest extensive fauna in Europe is that of the Baltic Amber, in the Lower Oligocene. Back of that, during the vast period represented by the Eocene and Paleocene, there are only a few scattered remains, the most instructive being a beautiful dragon fly (*Triæschna gossi* Campion) from the Upper Eocene (Bagshot Beds) of Bournemouth. In this country we are more fortunate, since the extensive deposits of Green River in Wyoming and White River in western Colorado and eastern Utah are certainly Eocene, not Oligocene as has been sometimes supposed. There

are also other Eocene localities, such as that near Rifle, Colorado; and quite recently a small series of Coleopterous elytra has been obtained in Colorado in beds which are probably quite near the base of the Tertiary. The value and importance of these older Tertiary insects has never been appreciated; Scudder, who described nearly all of them, was not aware of their relative antiquity. In his work on the Tertiary weevils Scudder brings out very clearly the radical difference between the Florissant Fauna and what he calls the Gosiute Fauna, although "the deposits of both (Florissant and the Gosiute Lake) are presumably of Oligocene age." When we consider that according to the best information we now possess Florissant is Miocene and the Gosiute Lake Eocene, all surprise at the absence of species common to both vanishes.

The Rocky Mountain Eocene insects present a rather remarkable assemblage, not so much on account of what is present, as for the absence of important groups. Coleoptera, Diptera and Hemiptera are numerous, but prevailingly small. There are a few Orthoptera and some good Odonata. A few very poorly preserved ants were described by Scudder, together with some parasitic Hymenoptera and a good sawfly; but no bees have ever been obtained, and there is only a single fossorial wasp. No Lepidoptera have yet been seen. Perhaps the most interesting Dipteron is an Oestrid, represented by numerous larvæ.* Various families of the higher Diptera were represented by genera which still exist. It is possible that the conditions of deposition partly explain the character of this Eocene fauna, or series of faunulæ, and it is reasonable to expect that further collecting will greatly modify the statistics. At the same time we are lead to ask whether the complete modernization of Tertiary insect life had taken place at this early date; or rather, granting that the fauna so far as it goes is quite modern in aspect, whether the exuberance of types so characteristic of later times had yet developed. The condition of affairs may, in short, have been analogous to that observed in the Mammalia, which had by this time established the modern outlines, but had much development and diversification

*Dr. J. Bequaert calls my attention to the resemblance between these larvæ and those of the African genus *Dermatoestrus*. The imago of *Dermatoestrus* is unknown.

still ahead. The parallel is of course not exact, since insect genera are much more stable and long lived than those of mammals.

The fauna of Prussian Amber, of Oligocene age, is extraordinarily rich and beautifully preserved, the specimens resembling mounts in Canada balsam. In the museum at Konigsberg are over 100,000 specimens, while many exist elsewhere. Fake specimens are occasionally seen in collections, or specimens supposed to be in amber, but really in African Copal, of post-tertiary age. Putting aside all these, the perfectly genuine Oligocene amber collections are enormous, though only partly worked up. Ulmer, in a most remarkable work, has monographed the Trichoptera; Wheeler has done a like service for the ants; Meunier has described a great series of Diptera, and other authors have discussed smaller groups. Edmund Reitter has made a preliminary survey of the Coleoptera, indicating the recognisable families and genera, and a considerable number of apparently new genera not yet described or named. On looking over the lists, one notices first of all the richness of the fauna, the great abundance of genera and species. During mid-Tertiary times, the climate of the present Holarctic region was warmer than at present, and conditions seem to have been exceptionally favorable for an abundance of insect life. Since that time, the glacial period, or rather succession of glacial periods, has destroyed or driven out very many types, so that today we dwell in a relatively impoverished world, so far as the North Temperate region is concerned. Another remarkable thing is the lack of progress exhibited in the two million years or so since the time of the amber. Wheeler, referring to the ants, says that since the amber "the family has not only failed to exhibit any considerable taxonomic or ethological progress, but has instead, suffered a great decline in the number of species and therefore also in the variety of its instincts, at least in Europe." Ulmer, speaking of the Trichoptera, says that the amber fauna is quite as highly developed as that of modern times. The presence of numerous extinct genera in all groups bears witness rather to the faunal contraction already mentioned than to any uniform and general advance of organization. There are, indeed, some archaic genera, but such also exist today. It must be said, however, that the bees, which I have studied, *all* belong to extinct genera, and

Very recently, Mr. R. C. J. Swinhoe has sent me many specimens of Burmite, or Burmese amber, containing insects. This material occurs in clay beds of Miocene age, but it is evident that the amber was washed into them from higher levels, and it is not impossible that it is much older. The insects, so far as yet examined, have rather a primitive aspect, but the number of species as yet available is small. I find a Termite (*Termopsis*), a Psocid (doubtfully referred to *Psyllipsocus*), an Hemipteron of the interesting genus *Enicocephalus*, a *Trigonalys*, two extinct genera of Evaniidæ, both very small, an extinct genus of Empididæ, a *Sciara* and a species of the Psychodid genus *Trichomyia*. It is expected that more of this amber from Burma will be available, and we may ultimately get a good idea of a Tertiary insect fauna in tropical Asia.*

It is not necessary to review the quite numerous deposits containing Miocene insects in Europe, but we cannot overlook our own wonderfully rich Florissant shales. A short distance west of Pike's Peak, resting on a base of granite, is an ancient lake-basin containing laminated shales full of insect and plant remains. The preservation of the specimens is often excellent, even such minute and fragile creatures as Aphids being represented by numerous recognizable genera and species. The number of described species is now about 1300; by far the largest Miocene insect fauna known in the world. The corresponding European deposit, at Wangen on the Rhine, has 465 described species, but many others remain undescribed in the University at Zurich. It is certain, however, that were all the Wangen fossils worked up, the series would still fall far short of that of Florissant.

The presence of certain types which probably reached America from the Old World, and the absence of any distinct Neotropical element, suggest that the Florissant beds were laid down subsequent to the beginning of the migration from Asia by way of what is now Behring Strait, but before North and South America were connected; that is to say, in the latter half of the Miocene. Should mammals be found at Florissant, early forms of the elephant group may perhaps be expected. Perhaps the most remarkable of all the Florissant insects is the genus *Glossina*, today known as an inhabitant of tropical Africa,

*Since this was written a new lot has come to hand, including many species, one an Elaterid beetle nearly 20 mm. long.

where it carries parasites which cause fatal diseases to man and animals. No less than four species of tsetse flies have been found fossil at Florissant; and the extraordinary thing is, that these alone represent the higher Muscoids in the fauna, there being no true Muscidæ, no Tachinidæ, Dexiidæ or Sarcophagidæ. Anthomyiidæ and various acalyptrate families appear to be rather common. Bombyliidæ are abundant and very varied, consisting of twelve genera now extinct, a doubtful *Geron*, and a species of the living but rare and widely scattered genus *Dolichomyia*. It is possible that the Bombyliidæ then occupied, as parasites, the position now chiefly taken by the Tachinidæ. The Anthracine Bombyliids, now so prominent in the Rocky Mountain fauna, appear to have been entirely absent; their advent during the later part of the Miocene may have been one of the main causes of the disappearance of so many of the Florissant genera, though the competition of the Tachinids must also have been important. We get here a glimpse of the drama of insect life; the development of a series of types occupying a definite place in the scheme of nature, and their replacement by other more vigorous or aggressive forms, coming from some remote region of the world. Another astonishing Florissant fossil, discovered by Mr. S. A. Rohwer, is a species of Nemopteridæ, those remarkable insects with long narrow hind wings, expanded at the end. I could not separate the species from the Old World genus *Halter;* but Navas, after examining my type, concluded that a distinct genus was indicated. He accordingly named it after Pere Marquette, and the insect becomes *Marquettia americana* (Ckll.)

Professor Wickham, who has occupied himself with the Florissant Coleoptera for several years, is now able to enumerate nearly 570 species; his latest paper, on the Elateridæ, records 43 members of that family, as against 23 species described from all other deposits of the world combined. The beetle fauna has an entirely Holarctic facies, though extinct genera are fairly numerous. The Rhynchophora are extraordinarily numerous; very much more so than in the Miocene of Europe. On the other hand, the Chrysomelidæ are relatively scarce, and there are no Histeridæ or Cicindelidæ. Among the causes which have led to the contraction of the Rocky Mountain weevil-fauna since the Miocene, must evidently be the great reduction in the number of genera of woody plants; the total

elimination of the figs, magnolias, chestnuts, elms, *Ailanthus*, and various other kinds of trees. This change in the vegetation would necessarily affect thousands of plant-feeding insects, while the climatic changes giving rise to it would favor the increase of many genera. Thus, the more we study the Miocene insects of Colorado in comparison with those of today, the more evident it becomes that the differences observed are due, not so much to any definite forward evolution, as to migrations and the extinction of a certain number of genera. It is a very striking fact, however, that in particular groups, such as Aphididæ and Bombyliidæ, the genera are practically or quite all extinct, while in others they are little different from those now inhabiting North America. The most conspicuous contrast between Florissant and the Baltic amber is seen in the bees. All the amber bees are of extinct genera; but of the 28 species of Florissant bees, only eight belong to extinct genera. Wheeler has recorded evidence that as far back as the Baltic amber, perhaps a couple of million years, the ants had many of the specialized habits they have today. Similarly at Florissant, we find that various kinds of gall-insects made galls as they do now, and leaf-cutting bees cut leaves in exactly the same manner.* Species of *Ficus*, both leaves and fruit, have been uncovered; and also a genuine fig-insect, which doubtless brought about fertilization as fig-insects do today.

From Florissant times up to the Pleistocene, we have no knowledge of the character of the North American insect-fauna. From the Pleistocene, however, a fairly large assemblage of beetles is known, and there is every reason to suppose that it will be greatly increased when more systematic search is made. The latest discovery of Post-tertiary beetles has been made in Florida; some specimens which reached me from Dr. E. H. Sellards the other day have been forwarded to Professor Wickham, who will report upon them.

The study of fossil insects adds another dimension, as it were, to the edifice of entomological science, and throws light on the broad problems of evolution. When insect remains in the

*Berry, in his excellent work on the Lower Eocene Floras of S. E. North America, recently published by the U. S. Geological Survey, figures a leaf of *Icacorea* showing numerous holes, and remarks that may indicate the work of a species of Megachilidae. The work is, however, entirely different from that of the leaf-cutting bees, and it would be a mechanical impossibility for any one of them to riddle a leaf in the manner shown.

rocks appeared to be few and scattered, the lessons to be learned from palæoentomology could not be clearly perceived. Today the situation is very different, and evidently our present knowledge of the subject is small compared with that which the next generation will possess. Not only are new localities being discovered every year, but the old ones are for the most part, at least, still as fertile as ever. There already exist in museums many hundred, perhaps thousands, of species of fossil insects which await description; many collected years ago, and strangely neglected. Entomologists certainly have the excuse that they have been more than busy with the existing insects, and with economic problems; but one might have expected that the greatest and most progressive nations would have produced a fair succession of students of fossil forms. England, until now, has neglected the splendid Gurnet Bay collections preserved in the British Museum; in America the Florissant beds were long unworked, and there are still museums where Florissant insects are preserved, without any steps being taken to get them described. In Germany, the revival of active interest in the amber fauna is comparatively recent, and on visiting the famous Oeningen deposit a few years ago, I found it had been neglected since the time of Heer. At Zurich, where Heer's types, and many undescribed species which he did not live to publish, are carefully preserved, there is no one to continue the work. Handlirsch in Vienna has produced his great work on Fossil Insects, which enormously facilitates the labors of all who are interested in the subject, and there is indeed much evidence of a new birth of palæoentomology; but many more collectors and students are needed.

Not only this, but for the development of what we may call the philosophy of entomology, of that historical perspective without which the most elaborate monographs are seriously inadequate, it is necessary that the ordinary working entomologist should take account of the fossil members of his group. It is truly extraordinary that when Scudder published his great monograph on the Tertiary Insects of North America, hardly any attention was paid to it, and for many years there was practically no one to give it, or any part of it, the serious and critical study it deserved. The organization of biological and entomological knowledge is rapidly advancing in these

days of increasing scientific activity. We like to believe that we live in the Age of Science; but there are many more lunatics than scientific investigators in the country. When science really comes to its own, when the spirit of science permeates the community, there can be no doubt that the whole face of our civilization will be changed. If, however, the material advance due to science is unaccompanied by a corresponding moral elevation; if scientific discovery merely sharpens the edge of the weapons of discord, the disruptive forces in society, it can only hasten the collapse of human civilization. Thus we understand why, in the warring countries of Europe, every effort is made to keep alive the sacred flame in the temples of pure science. Academies meet, journals are published, researches are continued, not from any indifference to the events going on around, but to preserve, so far as may be, the habit of mind which rises above the dust of conflict, and looks toward the future of mankind.

If Europe can do this in war, how much more should America in peace; unless, indeed, we are obliged to confess ourselves relatively incapable of the larger vision. The Republic of Science is the greatest of all republics, and those conscious of having a part in the common task of the world cannot cease to co-operate, even in times of war. Thus, in a large sense, philosophical entomology, entomology which recognizes the entire scope and purpose of our science, is the most serviceable, the most truly economic, of all. It ceases to be mere science, and blending with those deeper feelings which we call religion, transforms our whole point of view.

APPENDIX.

HYMENOPTERA.

Protofoenus new genus (Evaniidæ).

Antennæ long, filiform; head broad, eyes rather small; mandibles strongly incurved and sharp apically, apparently quite simple; legs slender, hind tibiæ long and slender, not at all clavate; abdomen of female thick and rather short, with a rather long very slender ovipositor directed obliquely upward; wings ample, venation of anterior pair nearly as in *Foenus*, with the same kind of first discoidal cell, in the same position, but the apical side of submedian cell oblique, not bent in middle, and the basal side of second discoidal as shown in figure. The second antennal joint is distinctly modified, broadly pyriform. The scutellum is elevated, rounded in lateral profile.

Protofoenus swinhoei n. sp. (Fig. 1, A, anterior wing; B, abdomen; C, hind leg; D, head; E, base of antenna; F, mandibles).

Length about 4.6 mm.; wings translucent, the apical half suffusedly dusky, stigma and nervures fuscous; antennæ, face and front black, but the broad cheeks entirely honey-color; thorax and abdomen black; legs mainly dark, but hind femora pallid except at base, and hind tibiæ except at apex; the minute claws appear to be quite simple.

In Burmese amber; received from Mr. R. C. J. Swinhoe.

This remarkable little insect caused me much perplexity. It seemed to resemble the Braconidæ, but it was seen to possess a very well developed costal cell. From a sketch of the venation, omitting the characteristic first discoidal cell, which I had not at first clearly seen, Messrs. Rohwer and Gahan were positive that it could not be a Braconid, and suggested affinity with the Proctotrypidæ. On further study, viewing the specimen at different angles and in different lights, I was able to make out all the characters which placed it positively in the Evaniidæ, nearest to *Foenus*, from which it differs in the shape of the abdomen and form of the hind legs. It is a primitive type related to *Foenus*, possibly the ancestral form of that genus, although on superficial examination one would not suspect the relationship.

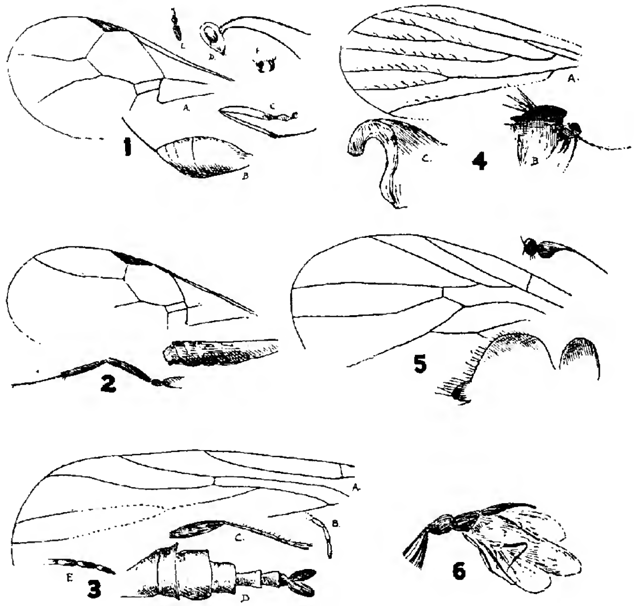
Hyptiogastrites new genus (Evaniidæ).

Related to *Hyptiogaster* but still more primitive; marginal cell truncate at base; first discoidal small, not produced apically; head much broader than thorax; antennæ long, filiform, apparently as in *Evania;* male abdomen cylindrical; legs of moderate length; claws small; hind tibiæ thickened, tarsi long, the hind femora, tibiæ and tarsi subequal; hind spurs short.

Hyptiogastrites electrinus n. sp. (Fig. 2, anterior wing, abdomen and hind leg).

Male. Length about 2.5 mm.; black, the legs and antennæ dark fuscous; cheeks black; wings perfectly hyaline, stigma fuscous, nervures light brownish.

In Burmese amber; received from Mr. R. C. J. Swinhoe.



EXPLANATION OF FIGURES

Fig. 1. *Protofoenus swinhoei* Ckll.
Fig. 2. *Hyptiogastrites electrinus* Ckll.
Fig. 3. *Sciara burmitina* Ckll.
Fig. 4. *Trichomyia swinhoei* Ckll.
Fig. 5. *Electrocyrtoma burmanica* Ckll.
Fig. 6. *Myodites burmiticus* Ckll.

DIPTERA.

Sciara burmitina n. sp. (Mycetophilidæ).

(Fig. 3, A, wing; B, palpus; C, leg; D, abdomen; E, end of antenna).

Male. Length 4.4 mm.; black, the legs brownish; palpi slender, last three joints subequal; antennæ thick, tapering and slender apically, the middle joints longer than broad, the apical ones slender, much as in *S. sendelina* Meunier; thorax very convex in lateral profile, the dorsulum forming half a circle; wings hyaline, apparently slightly dusky, with dark veins, subcosta entire; legs very long; femora thick; tibiæ very

long and slender, with minute short hairs; hind coxæ longer than head; abdomen elongated.

The wings are crumpled, so that it is impossible to get exact measurements, and the figure given, though approximately correct, must be regarded as diagrammatic. The complete subcosta is an archaic character, and might suggest a distinct genus, but the living *S. lugens* Johannsen, as figured, is not very different.

In Burmese amber (Burmite); received from Mr. R. C. J. Swinhoe.

Trichomyia swinhoei n. sp. (Psychodidæ).

(Fig. 4, A, wing; B, head and thorax; C, end of abdomen).

Male. Length about 1600 microns, wing about 1410 microns long and 560 broad. Dark brown or black, the wings clear hyaline. Antennæ long and slender, apparently 16-jointed, the joints beyond the second long and slender, hairy; palpi of moderate length; legs slender; wings with marginal fringes, and long hairs on the veins, venation as shown in figure. The thorax, in lateral profile, is produced anteriorly above, angular; the scutellum is prominent. Unfortunately the anal field of the wings cannot be seen, but the insect certainly appears to belong to *Trichomyia*, not to *Sycorax.*

In Burmese amber, received from Mr. R. C. J. Swinhoe. It is in the same piece of amber as *Sciara burmitina.* The genus *Trichomyia* appears to be on the wane. Meunier describes no less than eight species from Baltic amber (Oligocene), but Brunetti does not report the genus at all in his account of the Psychodidæ of India. In North America we have only a single species listed in Aldrich's catalogue, and that is Mexican.

Anthomyia (s. lat.) **laminarum** n. sp. (Anthomyiidæ).

Female. Length 6 mm., thickset (form nearly as in *Spilogaster*), black; wings about 4 mm. long, broad, hyaline, costa with short black bristles, costal margin conspicuously elevated and convex before end of auxiliary vein; head shaped (in lateral profile) much as in Williston, N. Am. Diptera, 3rd edition, p. 335, fig. 27, the top of head broad, and with only very delicate bristles, though the front has conspicuous bristles; dorsum of thorax, anterior to wings, with no long bristles, but there are long bristles at level of wings, the whole arrangement here apparently as in *Lispa;* abdomen stout, bristly, with a distinct short ovipositor; the depth of abdomen (doubtless increased by pressure) is 2.3 mm. The venation is much as in Williston's figure of *Choristoma.* Auxiliary vein complete, but pale; first vein ending soon after auxiliary (a deceptive appearance of its continuing parallel with the margin is due to the lower edge of the thick costa); anterior cross-vein about middle of discal cell, being 1010 microns from apex and about 1024 from base; first posterior cell not contracted at apex; width (depth) of submarginal and first posterior cells at vertical level of end of second vein each about 432 microns; superior apical angle of discal cell practically a right angle; apex of third posterior cell (angle between fifth vein and lower margin of wing) very acute.

Wilson Ranch, Miocene shales of Florissant, Colorado (Wickham). Readily known from the two previously described Florissant Anthomyiids by the anterior cross-vein being practically at the middle of the discal cell. These fossils cannot be definitely referred to modern genera, many of the essential characters being invisible. There is no doubt that the present insect is generically distinct from the other two, as genera in this family are now understood.

Electrocyrtoma new genus (Empididæ).

Minute flies resembling the modern genus *Cyrtoma* Meigen, but the rather large antennæ have a long terminal bristle; hind tibiæ and basitarsi not at all thickened; abdomen short, not extending much beyond hind femora; no detached vein in middle of wing below fourth; a considerable interval between separation of third vein from second and anterior cross-vein. Thorax greatly elevated, finely hairy; scutellum prominent, hairy; humeral cross-vein straight (not oblique); discal cell entirely open, but a slight bend in fourth vein at a point where apex of cell probably existed in an ancestor; end of anal cell and of second basal nearly in the same line; legs long and slender, but anterior femora thickened basally, the base about twice as broad as the apex.

Electrocyrtoma burmanica n. sp.

(Fig. 5, wing, antenna and dorsal profile of head and thorax).

Male. Black, with perfectly clear wings; length about 1280 microns. The following measurements are in microns: length of antennæ, 256; width of anterior femora near base, 80; length of anterior tibiæ, 352; length of abdomen (approx.) 640; length of hind femora, 464; of hind tibiæ, 416; of hind basitarsi, 208; of wing (approx.), 1040.

In Burmese amber, received from Mr. R. C. J. Swinhoe.

The loss of the outer side of the discal cell in the Empididæ appears to be a specialization. It is surprising to find in Burmese amber, the fauna of which seems on the whole to possess rather primitive characters, an insect more specialized than the ordinary Empididæ of modern times.

There is no affinity with any of the species described from Baltic amber.

COLEOPTERA.

Myodites burmiticus n. sp. (Rhipiphoridæ). (Fig. 6).

Length about 3.5 mm.; head, antennæ, prothorax and elytra black, but thorax behind level of elytra and dorsum of abdomen (except toward apex) pallid, probably ferruginous; antennæ flabellate, with at least five or six long processes; elytra short, scarcely reaching beyond base of abdomen; wings ample, hyaline, the costa pale ferruginous; legs slender, ordinary.

In Burmese amber (Burmite), received from Mr. R. C. J. Swinhoe.

I cannot distinguish this from the modern genus ***Myodites***, but it is so placed in the amber that it is impossible to get a good view of the details of structure under the microscope. A species of ***Myodites*** has been recorded from the Oligocene of Rott, in Germany. The fossil seems to belong to ***Myodites*** rather than to ***Emenadia***, which occurs today in the India region.

CAMPTOPELTA, A NEW GENUS OF STRATIOMYIDÆ.

S. W. Williston.

During a vacation the past season in New Mexico I found relief from monotony and much pleasure in renewing my acquaintance with the Diptera, a study to which I have given many years of my life, but which, perforce, has been interrupted during the past eight years. During the months of April and May I collected, almost daily, in the vicinity of Socorro for my friend, Dr. Aldrich. The collecting region was, for the most part, on the mesa near the foot of Mt. Socorro, and occasionally along the "bosque" of the Rio Grande. The mesa is a dry upland plain, with an altitude of about five thousand feet, covered with mesquite, with numerous dry arroyas traversing it and leading into the mountains. As would be suspected, its dipterous fauna consists chiefly of bombyliids and asilids, with some dexiids and mydaids. Of the first of these families I collected nearly forty species, and saw others that I did not have the opportunity to capture. Syrphids, empids and dolicopodids were few in number, as were the nematocerous flies, with the exception of the Culicidæ, which, after the summer rains, occur in extraordinary numbers. Most of my specimens came from the dry arroyas, very few indeed from the level plains.

The only stratiomyid I saw during the season was a single specimen of a small species that I referred in the field to an unknown genus. I searched for it afterward without success. Rather curiously I took at the same time and place two specimens of *Epacmus willistoni* O. S. that I never saw afterward.

On a recent visit to Dr. Aldrich at La Fayette, my interest in the stratiomyid was renewed. I can find no account of it in recent literature, and venture to describe it as having some features of peculiar interest.

Camptopelta, genus new.

Female. Bare. Front smooth, broad, convex, not narrowed above. Ocelli equidistant. Antennæ situated below middle of head, short. First two joints short, the second broader than long; third joint (flagellum) oval, composed of six segments; first segment longest, a little

shorter than the next two together; fourth segment tapering to the slender style; style slender, about as long as the third and fourth segments together; fifth, or basal segment of style, minute, about as broad as long; sixth segment three or four times as long as the fifth, tapering to an obtuse point and ending in a short, slender hair. Face below the antennæ a little shorter than the first six segments of the antennæ combined; nearly straight, directed downward and forward, somewhat compressed at tip from side to side. Cheeks and posterior orbits of nearly equal width, only moderately broad. Eyes bare, subcircular. Scutellum strongly convex, somewhat thinned, but not furrowed before its margin; unarmed. Abdomen smooth, convex, tapering from the broad second segment; fourth segment but little more than twice as broad as long; seventh segment minutely visible at the end of the ovipositor. Wings with veins complete; four posterior veins, the fourth separated from discal cell by a distinct crossvein; the second vein arises about opposite the proximal end of the discal cell, and a little before the short anterior cross-vein; no anterior branch to the third vein; anal cell rather broad, terminating some distance before the wing margin, the sixth vein convex. Legs simple.

Camptopelta aldrichi, species new.

Female. Shining black, bare. A large, light yellow spot on each side of the front below, narrowly separated, their upper borders in the same straight line, extending down along the orbits to about the middle of the face, convex on their inner sides. Antennæ black. Cheeks black below the eyes. Orbits on the inferior half light yellow. A light yellow stripe from the humeri to the root of the wings. The narrow lateral margin of the first three abdominal segments yellow. Legs yellow, the femora broadly black; knees and tarsi light yellow, the tibiæ in the middle more luteous or brownish. Wings pure hyaline, the veins light-colored. Length 4–5 mm.

One specimen, near Mt. Socorro, New Mexico.

The position of the genus is a little doubtful. The minute seventh segment of the abdomen, together with the scutellum and neuration will at once separate the form from the Beridinæ. From the known Pachygastrinæ (not Pachygasterinæ, as Enderlein and Malloch spell it—gasteric, gasteritis!) it differs in the neuration; from the Clitellarinæ by the origin of the fourth posterior vein; from the Geosarginæ by the absence of a distinct arista. Upon the whole its position seems to be among the Stratiomyinæ, some forms of which, at least, have the second vein arising before the cross vein. From the known American genera it will be distinguished by the unarmed scutellum and the absence of the branch of the third vein.

However, it is a question how much reliance can be placed in this family upon the absence of this branch. This vein is disappearing in this family, and it is a well-known fact that disappearing organs are more or less inconstant in the individual, just as the wisdom teeth often are not erupted in the human individual. In *Odontomyia*, *Oxycera*, and other genera of the family its presence or absence is disregarded as a generic or even specific character; I am very skeptical of any genus that is based upon its absence exclusively, and that seems to be the condition in some of the more recently described genera of the Pachygastrinæ. So also, the origin of the fourth vein is not absolutely fixed in all genera.

In the latter part of May I found a species of *Geron* (Bombyliidæ) very abundant on several kinds of flowers in the canons of Mt. Socorro, and a little ways out on the plains. I could have collected hundreds of specimens had I chosen. I did capture enough, however, to show that about one in every twenty had a perfectly formed third submarginal cell. I could discover no other constant differences. Whence it follows that, in the definition of this and some other genera of the Bombyliidæ, as in several genera of the Stratiomyidæ, the number of submarginal cells does not have even a specific value. This species of *Geron* is a "sport" or "mutation" that has not yet been fixed by heredity, a developing character, apparently. *Rhabdopselaphus* Bigot was based upon a difference of the third antennal joint (*Geron trochilides* W. probably belongs with it) and with "submarginalibus tribus" cells. One of its type specimens in Mr. Verrall's cabinet has but two submarginal cells, but it is not at all sure that this genus also is not variable, and that Bigot made a mistake in his description.

Mr. Malloch, though he has never seen a specimen of *Lophoteles*, has expressed a doubt of the correctness of my generic determination of *L. pallidipennis* W.* Perhaps it is presumption on my part, in view of Mr. Malloch's knowledge of the family, to adhere to my opinion. Indeed, I long had a suspicion that not only was my species congeneric with Loew's type but that both species were identical! And this suspicion has been increased by Enderlein's discovery† of *L. plumula* Loew in Costa Rica! About the only difference he finds

*Annals Ent. Soc. Amr. 1915, p. 335.
†Zool. Anz. 1914, p. 311.

between the two is the lighter color of the knees. I may add that the figures made by v. d. Wulp for the Biologia, although himself an eminent dipterist, were not always strictly accurate in details, and it may be the differences Enderlein points out do not really exist, and that *L. pallidipennis* Williston is in reality a synonym of *L. plumula* Loew. I fear that Mr. Malloch overlooked Enderlein's paper, or he would also have discovered that his genus *Eucynipimorpha* is a synonym of *Psephiocera* Enderlein.

THE WING VENATION OF THE CERCOPIDÆ.*

Z. P. METCALF.

INTRODUCTION.

The present paper is the third and last of a series of papers on the wing venation of the Homoptera by the writer. The other papers have been published in the ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA, Volume VI (Metcalf 1913a and 1913b). These two papers together with one by Funkhouser (1913), one by Miss Patch (1909) and the present paper complete the studies of the wing venation of the families of the Order Homoptera, Comstock and Needham (1898–1899) having discussed the wing venation of the Cicadidæ in their original paper on the wings of insects.

In my studies of the wing venation of the Cercopidæ I have used about the same technique that was used in studying the wing venation of the Jassidæ and Fulgoridæ. That is, the nymphal wing pads were removed from specimens that had been killed in weak formaldehyde and mounted on a slide under a cover glass. These preparations were drawn by the aid of the Edinger drawing apparatus, various combinations of objective and oculars being used. Afterwards these drawings were carefully compared with fresh mounts of wings from other specimens and if it was found to be incorrect in anyway the original drawing was discarded and a new drawing made. As noted below, material was limited in certain genera but it is believed that most errors have been eliminated.

The adult wings from which the drawings were made were dissected out and mounted in balsam. From wings thus mounted drawings have been made by means of the Edinger drawing apparatus. The drawings of the adult wings are not intended to give a picture of the wing in any sense of the word but are supposed to show the course of the veins. No attempt has been made to represent the width of the veins, the lines drawn simply showing the main axes of the veins.

*Contributions from the Department of Zoology and Entomology of the North Carolina Agricultural College and Experiment Station No. 6.

MATERIAL.

In all, five of the six North American genera have been studied. The only genus of which I could not secure nymphal material is Philaronia Ball which, however, is quite close to certain other genera and its venational characters seem quite evident on comparing it with closely related genera. In the course of these investigations which have covered odd moments for the past eight years I have had abundant material of the following genera: Monecphora A. & S. (Tomaspis Stal), Lepyronia A. & S., Clastoptera Germ. In the genus Aphrophora Germ, I have had a fair amount of material but in the genus Philænus Stal, my material has been rather limited owing to the fact that the genus does not occur in eastern North Carolina at all and only to a very limited extent in the mountains. So that for material in this genus I have had to depend on material kindly sent me from Maine by Professor C. L. Metcalf.

THE FORE WING.

The fore wing of the Cercopidæ, at least of our North American genera, is rather thick and opaque, and the venation as a rule is not very distinct or if it is plainly visible it is broken up in fine reticulations so that the main venation is badly obscured. However, an examination of the nymphal wing pads shows a condition found among certain genera of the Cicadellidæ (Jassidæ) to which family the Cercopidæ are otherwise closely related.

In reviewing the trachea of the fore wing we find that costa is typically present in all genera studied lying as a single unbranched trachea parallel to the costal border. In the adult wing this makes the vein that thickens the costal border of the wing.

A subcostal trachea has been found in all the genera of the subfamily Aphrophorinæ. It has not been found in the single genus of the subfamily Cercopinæ that has been available for study, hence it may be presumed that it is absent in this subfamily. In the adult wings of the genera closely related to Aphrophora the subcostal vein is closely united with radius both basally and distally but throughout the center of its course it is rather widely separated from radius so that it cuts off an

oval cell that is rather characteristic of the venation of these genera. (Figs. 13, 15, 17, 19.) In Lepyronia (Figs. 5, 15) subcosta is so closely joined to the radius that a part of the branches of radius appear to belong really to subcosta. In the genus Clastoptera (Figs. 9 and 21) subcosta is free and runs from the base of the wing ending in the costal border about half way from the base to the apex of the wing.

Radius is typically three branched in the Cercopidæ. These branches represent in my opinion radius one, radius two plus three and radius four plus five. This relationship seems to be perfectly clear in Monecphora (Fig. 1) where radius one branches from the main stem and runs parallel with it for some distance and then turns toward the costal border. In the adult wing (Fig. 11) this basal part is all united in the same vein so that radius one appears as a branch of radius two plus three. In the genera closely related to Aphrophora there is a strong recurved trachea running from radius two plus three to the costal border (Figs. 3, 5, 7), this I believe represents radius one whose attachment has simply been shifted further and further distally.

No nymphs of any of these genera, however, show a typical radius one, *i. e.*, as a branch from the main stem of the radius. The adult wings of these genera also show a strong vein running from radius two plus three to the costal border.

In the genus Clastoptera (Figs. 9 and 21) there is no evidence of a radius one, unless we call certain fine branches which occur near the apical angle of the wing this trachea and consider the small dark colored cell at the apical angle, cell radius one. However, it is more likely that this represents radius two. Radius two plus three usually shows some fine lateral branches towards the tip but none of these are very constant and are not worthy of being named.

The medial trachea in all our genera that I have examined is unbranched. Thus it resembles very closely the condition that has been found in certain genera of the Jassidæ. The medial trachea lies very close to the radial trachea but the medial vein is in all of our genera closely connected with cubitus, so closely joined as to appear as a mere branch of cubitus.

In the three genera Aphrophora (Fig. 3), Lepyronia (Fig. 5) and Philænus (Fig. 7) cubitus is typically two-branched as it is in many other genera of the Homoptera that I have examined.

In Monecphora (Fig. 1), however, it breaks up into a number of fine branches toward the tip, and in Clastoptera (Fig. 9) it appears to be unbranched. The three anals are always present and the third is usually two branched. I believe that it is always two branched and that in those genera in which two branches do not show the results are due to the fact that it is quite impossible to always get the anal angle of the wing pad removed carefully. This is especially evident in our preparations of Philænus but our preparations of Monecphora have usually been good in this respect. Whether the trachea is present in this latter genus or not cannot be decided now but the forming vein is usually quite distinct in good preparations (Fig. 1).

THE HIND WING.

The hind wing of the Cercopidæ bears a striking resemblance to the hind wing of the Jassidæ. Although there are certain constant differences that are worthy of being pointed out.

Radius is typically two branched in all the genera of the Subfamily Aphrophorinæ. In the Monecphora, however, it seems to be typically three branched (Figs. 2 and 4). The first of these branches which I believe to represent radius one is very variable in its relationships. In some cases (Fig. 2) it is attached to radius two plus three and in other cases (Fig. 4) it is plainly a branch of the main stem of radius. In either case it is very weak and the only remnant of it in the adult wing (Fig. 12) is a short spur attached to radius two plus three.

Medius of the hind wing is unbranched in all of our genera thus it differs decidedly from medius of the Jassid hind wing which is typically two branched. As if to compensate for this difference cubitus is two branched in all of our genera excepting Clastoptera where it is unbranched, whereas in the Jassids cubitus is typically unbranched. The three anals are typically present. The third anal is two branched and the first anal is usually very closely related to cubitus.

SUMMARY.

The present paper homologizes the wing veins of the Cercopidæ with the veins of the other Homoptera.

The venation of the Cercopidæ is quite similar in general facies to the venation of the Jassidæ although there are constant

differences. The costal and subcostal trachea are universally present in the fore wings of the Cercopidæ, whereas they are of very irregular occurrence in the Jassidæ. In the Cercopidæ medius is usually unbranched and cubitus two branched, whereas in the Jassidæ medius as a general rule is two branched with one branch very weak and cubitus is for the most part unbranched.

In the hind wing radius is mostly two branched in the Cercopidæ just as it is in the Jassidæ. Medius, however, is unbranched in Cercopidæ but usually two branched in the Jassidæ. Cubitus is, on the other hand, usually two branched in the Cercopidæ but unbranched in the Jassidæ.

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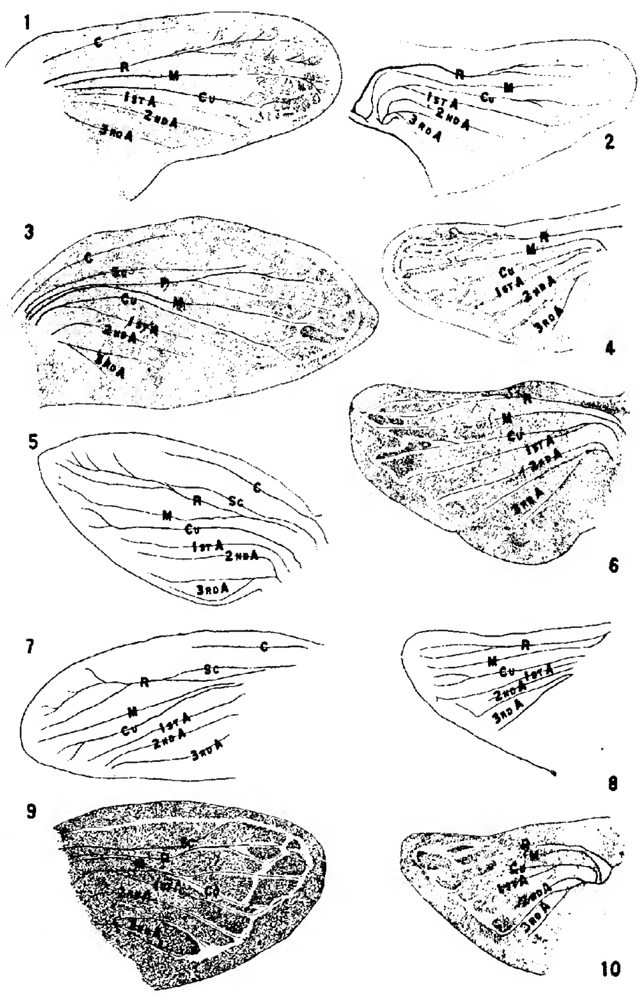
EXPLANATION OF PLATES.

Plate I.

Fig. 1. Fore Wing pad of Monecphora bicincta Say.
Fig. 2. Hind Wing pad of Monecphora bicincta Say.
Fig. 3. Fore Wing pad of Aphrophora quadrinotata Say.
Fig. 4. Hind Wing pad of Monecphora bicincta Say.
Fig. 5. Fore Wing pad of Lepyronia quadrangularis Say.
Fig. 6. Hind Wing pad of Lepyronia quadrangularis Say.
Fig. 7. Fore Wing pad of Philaenus sp.
Fig. 8. Hind Wing pad of Philaenus sp.
Fig. 9. Fore Wing pad of Clastoptera sp.
Fig. 10. Hind Wing pad of Clastoptera sp.

Plate II.

Fig. 11. Fore Wing of Monecphora bicincta Say.
Fig. 12. Hind Wing of Monecphora bicincta Say.
Fig. 13. Fore Wing of Aphrophora quadrinotata Say.
Fig. 14. Hind Wing of Aphrophora quadrinotata Say.
Fig. 15. Fore Wing of Lepyronia quadrangularis Say.
Fig. 16. Hind Wing of Lepyronia quadrangularis Say.
Fig. 17. Fore Wing of Philaenus sp.
Fig. 18. Hind Wing of Philaenus sp.
Fig. 19. Fore Wing of Philaronia sp.
Fig. 20. Hind Wing of Philaronia sp.
Fig. 21. Fore Wing of Clastoptera sp.
Fig. 22. Hind Wing of Clastoptera sp.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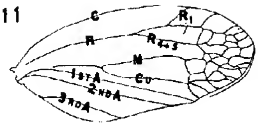

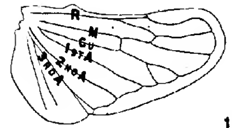

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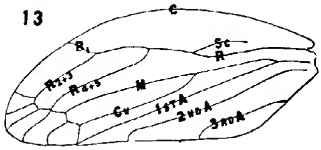

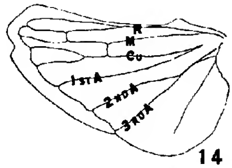

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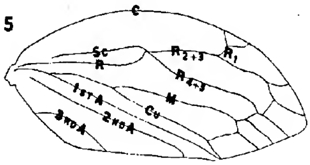

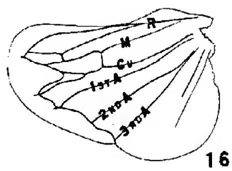

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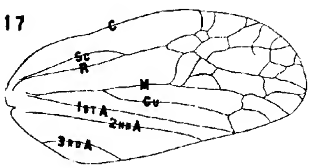

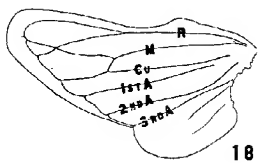

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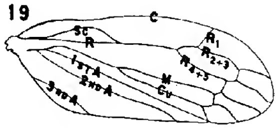

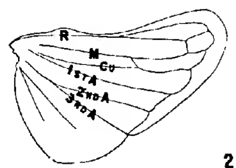

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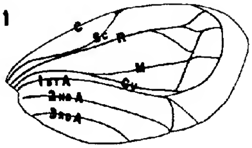

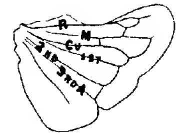

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Z. P. Metcalf.

FURTHER STUDIES ON HYDROMYZA CONFLUENS LOEW, (DIPTERA).*

By Paul S. Welch

INTRODUCTION

In a previous paper ('14), the writer reported the results of some observations on *Hydromyza confluens*, an aquatic dipterous insect which occurs abundantly about Douglas Lake, Northern Michigan. Parts of two seasons have since been spent in the same region and additional data, as well as confirmation of previously recorded observations, have been secured. The new material incorporated in this paper not only aids in completing our knowledge of the life history of this form but also throws new light on the interesting adaptations already described.

THE EGG

Description.—When first laid, the eggs (Figs. 1–2) are uniformly white, with a very slight tint of yellow. In clear, quiet water, they are usually more easily seen when submerged on the yellow water-lily petiole than when the latter is lifted from the water. They are elliptical in lateral view and subcylindrical (Fig. 3) in transverse section. A large number of eggs, removed from the petioles and measured, had an average length of 1.69 mm., the extremes being 1.54 and 1.76 mm. respectively. The maximum diameter, which is in a region well towards the more acute end, has an average length of 0.35 mm., the extremes being 0.30 and 0.40 mm. The ends differ distinctly in shape, one being bluntly pointed while the other is more rounded and is characterized by a depression in the apex. A straight, longitudinal, acute carina extends from end to end, occupying the mid-position in a deep, broad, longitudinal fossa, dividing it into two similar parts. This divided fossa comprises almost one-third of the periphery and is bounded laterad by two other longitudinal carinæ which extend almost parallel to the median carina, converging and uniting at the ends of the egg. The effect of this fossa is to give the egg a flat appearance on one side. Superficially, the chorion is smooth except in the region of the longitudinal fossa. The mid-longitudinal carina bears on its sides numerous minute, conical spines (Fig. 5). Similar minute projections occur on and near the vertex of each lateral, longitudinal carina. These minute processes are produced by an extra development of some of the columnar exochorionic units. The chorion is approximately uniform in thickness in all parts of

*Contribution from the University of Michigan Biological Station, No. 40, and the Entomological Laboratory, Kansas State Agricultural College, No. 20.

the egg-capsule except at the carinæ and in the depressions between them where it is distinctly thicker. The average thickness is about 0.0048 mm. The exochorion and endochorion are distinct, all variations in thickness being confined to the former which is composed in part of very minute, closely set, columnar units. For the greater part of its length, the median carina has an acute crest (Fig. 3) but near the ends it gradually merges into a lower ridge whose crest is broad and slightly rounded.

Under magnification, the surface of the chorion, except the region including the longitudinal carinæ and fossa, appears faintly but definitely reticulate, being composed of polygonal units (Fig. 4) which vary somewhat in shape and size but are usually hexagonal and more elongated in the direction of the long axis of the egg. Their average surface dimensions are about 0.112 and 0.056 mm. They contain numerous, minute, circular, uniformly distributed structures which give to the surface a granular appearance. These structures are of uniform size and appearance and are never contiguous. Structurally, they seem to be the ends of the columnar units which compose a great part of the chorion. Exclusive of the fossa and carinæ, they are present over the entire surface of the egg, being absent only on the narrow, homogeneous zones which separate the hexagonal areas.

Oviposition has not been observed and the writer has failed to secure eggs from females placed in the aquaria with food plants for that purpose. The identification of the egg has been made from a comparison with fully developed eggs dissected from females. The characteristic size, shape, and external structures, such as the carinæ, fossæ, and hexagonal areas, and a microscopical comparison of transverse sections of the eggs leave no doubt as to their identity. In addition, the writer secured a large number of eggs in various stages of development on the petioles of the water-lily and demonstrated the fact that the resulting larvæ develop the characteristic effect on the petiole, ultimately producing adults of *H. confluens*.

In connection with the dissection of females for developing eggs, it was noticed that, as in many other insects, there is a definite relation between the position of the egg in the ovariole and the shape of the completely formed egg. The larger, more pointed end is nearer the oviduct while the smaller, blunter end, which is characterized by a small terminal concavity, is nearer the terminal filament. It is then possible to determine accurately in the egg already deposited what was the previous relation to the reproductive organ.

Place and Method of Deposition.—The eggs are deposited singly at irregular intervals on the surface of the floating leaf petioles of the yellow water-lily (*Nymphæa americana* (Provancher) Miller & Standley). No eggs were found on the petioles of the submerged leaves and none were observed on other aquatic plants occurring in the vicinity of the yellow

water-lily beds. None were found on the petioles or other parts of the white water-lily (*Castalia odorata*) although both species of water-lily intermingle in the same beds. This restriction of the eggs to *N. americana* accounts for the constant relation of the larval and pupal stages to the same plant which is discussed in the earlier paper (Welch, '14, p. 136). Apparently, the female has the ability to recognize the food-plant even in the presence of numerous other aquatic plants, some of which present conditions similar to those of *N. americana* and are closely related to it.

Oviposition is constant with respect to the following features: (1) The long axis of the egg is parallel to the long axis of the petiole. (2) The surface of the egg in contact with the petiole is always opposite the carinæ and fossa. (3) The blunt end of the egg is directed towards the rootstalk and the acute end towards the leaf.

Eggs may occur anywhere from the leaf attachment to the rootstalk, even on petioles almost six feet long. As many as seventeen were found on a single petiole, scattered over a length of only one and one-half feet. An examination of a large number of petioles showed that while eggs are deposited on both the plane and convex surfaces, by far the greater number occur on the latter. The significance of this decided preference of the female in selecting the position of the egg is not known. The egg is rather firmly fixed to the surface of the petiole, apparently by a small amount of sealing fluid which accompanies the egg at oviposition. As will be shown later, the position of the egg determines the future position of the larva and pupa in the petiole.

As stated above, oviposition has not been observed and it is not known whether the eggs which occur on a single petiole are deposited by a single female or by several females. In the earlier paper, the writer ('14, pp. 138–139) called attention to the small variation in the maturity of the larvæ and pupæ and suggested that possibly the eggs on a given petiole were deposited at the same time by a single female. While this is still an open question, counter-evidence was apparently secured when, in the dissection of the ovaries of a considerable number of females, collected during the time when eggs were appearing in the field, it was found that no individual contained more than

nine approximately mature eggs at a time, the other eggs in the ovaries being distinctly undeveloped. It thus seems impossible for a female to deposit more than nine eggs during a single trip below the surface of the water, assuming that she could withstand submergence long enough to deposit the already mature or almost mature eggs, and it scarcely seems possible that the sojourn below could be so long that undeveloped eggs would have time to mature and be deposited also. Therefore, it seems improbable that, in instances where as many as seventeen eggs were found on a single petiole, all of them could have been deposited at one time by the same female. It is true, as pointed out, that the difference in the maturity among the larvæ or pupæ on a single petiole is often not marked but it may be that such a condition is due to the coincidence of the egg-laying period of a large number of females in that particular locality, a possibility which is borne out by the observation that in the region studied during the past five summers it often happened that many adjacent petioles contained larvæ of approximately the same degree of development.

Development of Eggs.—Owing to the fact that the writer was not able to secure the deposition of eggs in the laboratory, the egg period is not definitely known. Collections of eggs showing the least development were secured in the field, brought to the laboratory, kept under approximately natural conditions, and the last hatching dates recorded. This imperfect evidence points to an egg period of about six to eight days. The only noticeable external change which accompanies the development of the egg is a darkening of the color which begins to appear only a few hours before hatching.

Not only does a definite and constant relation exist in the position of the ends of the egg in the ovariole, but a similar relation exists in the orientation and development of the larva within the egg. The anterior end of the larva is invariably developed in the rounded, blunt, concave end, i. e., the one which is nearest the terminal filament while still within the ovariole. Furthermore, in all of the specimens examined, the ventral part of the larva is developed on the side opposite the carinæ and the dark, conspicuous mouth armature is curved in the same direction.

THE LARVA

Process of Hatching.—The place of emergence of the larva from the egg is a constant feature. The larva makes an exit hole through the egg capsule near the blunt, concave end, on the side next to the petiole. The position of the exit hole is determined by the position of the larva and is directly in front of the chitinous mouth armature, which, no doubt, is the instrument by means of which the opening through the shell is made. The exit hole is usually more or less circular in outline and somewhat larger than is necessary for the passage of the body of the larva. Occasionally, hatched eggs show a more extensive breaking down of the chorion next to the petiole. The larva bores directly into the petiole and there passes its entire existence. No evidence whatsoever was observed of any preliminary wandering of the larva after emergence from the egg. The latter always marks the position of the future abode of the resulting larva and pupa.

Recently Hatched Larva.—On emergence from the egg, the larva is milk-white in color, with the exception of the black mouth armature and the blackish caudal projections. The body (Fig. 6) is cylindrical, elongate, slender, and smooth. Measurements, made on living, recently hatched specimens, show a rather constant length of from 2.33 to 2.5 mm. The maximum diameter, in the region of the future thoracic segments, is approximately 0.29 mm. Intersegmental grooves are distinct but shallow. The anterior end of the body is rather bluntly rounded and shows no special structures, except the emergent teeth of the mouth armature. Posteriorly, the body is distinctly tapering and terminates in a pair of acute chitinous projections which bear the terminal spiracles. The integument is covered with very fine, pointed, conical projections. They are uniform in size and shape over the body except on the anterior margin of the first thoracic segment where they are a little more distinct. In most specimens, the translucency of the body allows the principal trunks of the tracheal system to stand out clearly. Two main, longitudinal tracheæ extend, one on each side, from the above-mentioned caudal, pointed, chitinized projections to the anterior region of the body, near the internal end of the mouth armature, where each divides into three branches. The finer details of this system have not been worked out.

Development of the Larva.—No striking external changes accompany the development of the larva. It increases in length and becomes somewhat more robust in proportion to the length. The yellowish tint in the color of the body becomes a little more apparent, the general body-surface smoother, and the intersegmental grooves less broad and deep, although they continue to be distinct. The larval period has not been accurately determined and no statement can be made at this time as to the rate of development.

The Relation to the Petiole.—Needham ('08), in describing the relation of the immature stages of *H. confluens* to the food-plant, designated the ultimate effect on the petiole as a *gall.* This same form of designation was followed by the writer ('14) in his first paper on this insect. However, subsequent work led to the investigation of the problem of whether the action of the larva on the petiole results in the production of a true gall or whether the superficial appearance of the infested petiole is merely a case of gall resemblance. Attention was called in the writer's earlier paper ('14, p. 137) to the observation that not all infested portions of the petioles showed swellings and often the diameter was not increased at all.

Specimens of the so-called galls were secured in all stages of development and sections of the same were made with the view of determining whether the growing larva produced any change in the character of the plant tissue in its immediate vicinity. An examination of these sections and a careful comparison with similar sections of the normal petiole showed that no change in the surrounding tissue occurs, that the relation of the larva to the petiole is merely one of simple interior excavation of the latter by the former and that the increase in diameter which sometimes appears is due to foreign accumulations within. The only change which was detected in the tissues was a brownish discoloration of the cells which bound the cavity made by the larva. Since the term gall is properly restricted to an abnormality in plants in which the causative factor leads to the development of tissues that differ from the normal ones, it becomes evident that the immature stage of *H. confluens* does not produce a true gall and that the occasional ovoid swelling of the petiole is not the result of an excrescence.

THE ADULT

In the writer's earlier paper ('14), a number of observations on the habits and activities of the adults were presented, and subsequent studies have yielded data which are confirmatory of the same. In addition, a few new data were secured which seem worthy of record.

Food Habits.—The relation of these flies to the yellow water-lily has been discussed somewhat in detail in the above-mentioned paper (pp. 145–147) and the possibility of nectar being produced by the flowers of *N. americana* and serving as a food for these insects was pointed out. This matter is still in doubt but the behavior of the flies in the flowers offers circumstantial evidence in favor of such a conclusion. However, it appears that the flies have other means of solving the food problem. Adults were repeatedly observed feeding on the exposed tips of the stamens. In most cases, this behavior was too long continued to be interpreted as a mere random inspection or testing of the stamen surface. The character of the food secured from the tips of stamens is not known. Possibly the pollen serves as food. Occasionally, flower stalks were, by different mechanical agents, broken off above water and partly stripped down, exposing a broken end on which an exudation of the liquid substances of the plant occurred. Flies often gathered in considerable numbers on such broken stalks and fed there for long intervals.

It also appears that these flies do not confine their feeding activities wholly to the yellow water-lily. Occasionally, adults of *Chironomus* sp. were found dead on the water-lily leaves and many of them, in the process of rapid disintegration, were discovered by these flies, the latter clustering about the dead insects and performing feeding movements. The evidence seemed conclusive that the flies were feeding on the juices of the dead insect. A number of experiments were tried by securing the bodies of *Chironomus* sp. and, after allowing them to lie in water for several hours, they were placed on the water-lily leaves where the adults of *H. confluens* were abundant. It was shown in this way that the dead insects had a distinct attraction for the flies, the latter seeking them rather quickly and definitely when not too remote from them. This response was so definite that the writer used the dead insects as a trap for the flies, thus facilitating the collection of the latter.

Light Relations.—No attempt has been made to carry on refined experiments on the behavior of these flies. However, observations and some rough field experiments were made on the relation of *H. confluens* to light, the results of which will be given in brief form.

A study of the habits of these flies in the field has shown that they are active during the day and are found in large numbers on the upper surfaces of the floating water-lily leaves. Very few were observed in any other situation. It thus appears that since the water-lilies grow in maximum exposure to sunlight and are never shaded, the flies prefer well-lighted conditions and positive phototaxis is suggested. A number of experiments were made by placing various lots of flies in a glass tube, closed at both ends and equipped with a close-fitting cover of heavy, black paper which enveloped about one-half of the length of the tube, other conditions remaining unchanged. By placing this tube in various positions with reference to the light and reversing it after certain intervals of time, the reactions of the insects could be noted. Irrespective of the position of the tube, the flies reacted positively to the light by seeking actively the uncovered end of the tube. These tests were repeated many times with the same results. The migration from one end of the tube to the other as the latter was reversed was continued over and over again without any appreciable change in the character of the response. Frequent use was made of this response in the collection of flies for other purposes and in the transference of individuals from one vial to another or from one breeding jar to another. While no experiments were carried on in order to determine whether any difference exists in the reaction by the different sexes, collections of flies from the top surfaces of the water-lily leaves, taken at random, showed no noteworthy difference in the number of males and females.

In the earlier paper, the writer ('14, p. 144) pointed out the probable method of oviposition by the female, namely, passage into the water on the under surface of the leaf and down the petiole to the places where the eggs occur. The discovery of the eggs makes this assumption all the safer. It thus appears that although the female is distinctly positive in reaction to light, this positive phototaxis is overcome by the stimuli inducing oviposition since the passage into the water is accompanied by a reduction of the light. Furthermore, the positive reaction to

light seems also to be overcome by the attraction to food since large numbers of the flies have been found on numerous occasions crowded into but slightly opened flowers of the yellow water-lily, the interiors of which were dark.

Distribution.—Attention has already been called (Welch, '14, p. 140) to the peculiar local distribution which was so marked in the Douglas Lake region. The observations of two additional seasons show that such a distribution is practically the same from year to year. Observations in other localities where *H. confluens* occurs would be of interest in this connection.

Thus far, *H. confluens* seems to have been reported only from Canada, Michigan, and New Jersey. However, there is reason to believe that it is more widely distributed than these meager data would indicate. While making a very hasty examination (June 27, 1915) of the life of the protected bays of Cedar Point, near Sandusky, Ohio, the writer found this fly, in the adult stage, in some abundance on the leaves and in the flowers of the yellow water-lily. None of the immature stages were found but this failure was due, no doubt, to the very superficial examination, lack of time preventing a thorough survey of the situation. Both sexes were present and several pairs were observed in copulation. Individuals collected at that time were bearing the pollen of the yellow water-lily and a few specimens almost completely covered with pollen were taken from the flowers. Evidently they were playing an active part in the cross pollination of these plants. Fulton ('11, p. 300) states that he found a number of flies visiting the yellow water-lilies, "*Nymphæa advena*," about Cedar Point but the particular species are not designated and his paper contains only a list of the Stratiomyidæ. Bembower ('11) studied the insect-pollinated plants of the Cedar Point region and while it was found that Diptera were collected in connection with *N. advena*, the different species are not indicated.

SUMMARY

1. Further studies on *Hydromyza confluens* in the vicinity of Douglas Lake, Michigan, confirm observations previously reported and yield new data on life history and behavior.

2. Eggs are deposited singly and irregularly along the submerged petioles of the floating leaves of the yellow water-lily (*Nymphæa americana*). Oviposition apparently does not occur on other plants.

3. The egg has certain definite and invariable external characters which facilitate identification, viz., the dissimilarity of the two ends, and the large, longitudinal fossa divided by the longitudinal carina.

4. Certain constant features with respect to the orientation and oviposition were noted: (a) In the ovariole, the blunt, concave end of the developing egg is nearest the terminal filament. (b) On the petiole, the blunt end is directed towards the rootstalk. (c) The long axis is parallel to the long axis of the petiole. (d) The side of the egg opposite the fossa and carina is in contact with the petiole. (e) The anterior end of the larva is developed in the blunt, concave end of the egg. (f) The ventral part of the larva appears to invariably develop on the side opposite the carina.

5. Incomplete evidence indicates that the occurrence of more than 7-9 eggs on a single petiole is due to oviposition by two or more females.

6. The position of the egg invariably marks the future position of the so-called "gall."

7. Microscopic examination of infested portions of the petioles shows that a true gall is not formed, the result being due to mere interior excavation.

8. In addition to the possible production of nectar by *N. americana* and its use as food, the adults were observed feeding: (a) on the exposed tips of stamens, possibly consuming the pollen; (b) on the exudation of broken, emergent flower stalks; and (c) on the dead bodies of certain insects (*Chironomus* sp.).

9. Field observations and experiments indicate that the adults exhibit a distinct, positive reaction to sunlight. It appears, however, that this positive phototaxis is overcome by the stimuli inducing oviposition and by the stimuli inducing the search for food.

10. Adults of *H. confluens* were collected about the yellow water-lily beds at Cedar Point, near Sandusky, Ohio, and evidence pointed to them as active agents in the cross pollination of these plants in that locality.

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EXPLANATION OF PLATE III

Fig. 1. Outline of egg showing surface which bears fossa and carinæ.

Fig. 2. Outline of egg showing shape when viewed ninety degrees from position indicated in Fig. 1.

Fig. 3. Egg capsule as it appears in transverse section.

Fig. 4. Camera lucida drawing of reticulation which appears on surface of egg capsule.

Fig. 5. Transverse section of median carina of egg.

Fig. 6. Recently hatched larva.

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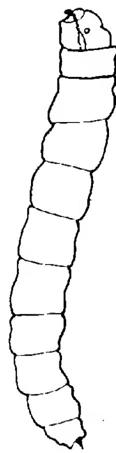

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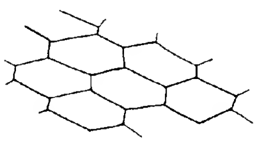

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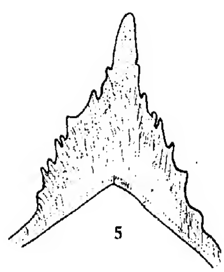

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P. S. Welch.

STUDIES ON COCCOBACILLUS ACRIDIORUM D'HERELLE, AND ON CERTAIN INTESTINAL ORGANISMS OF LOCUSTS.

By E. MELVILLE DUPORTE AND J. VANDERLECK,
Macdonald College (McGill University).

PART I. EXPERIMENTS ON THE CONTROL OF LOCUSTS BY THE USE OF COCCOBACILLUS ACRIDIORUM D'H.

A. Historical Resume.

Coccobacillus acridiorum, the causal organism of an epizootic disease of locusts, was isolated in the State of Yucatan, Mexico, in 1910, by Dr. F. d'Herelle from the South American migratory locust *Schistocerca americana* Drury. He had observed that during the previous year the swarms migrating northward into Mexico from the confines of Guatemala showed evidence of the presence of an epizootic. The mortality in the swarms increased each year until 1912, when the disease had destroyed the locusts to such an extent that no swarms migrated into Mexico. D'Herelle was able to produce disease and death by inoculating healthy locusts with a culture of the organism which he isolated from the diseased locusts. The results of his experiments led him to believe that the use of this organism would have successful results in the control of locusts.

In 1911–12 he was given an opportunity to test the effectiveness of his cultures against *Schistocerca paranensis* Burm. in the province of Santa Fe, Argentina, where his attempts met with a decided success.

Results obtained by Sergent and Lheritier in Algeria during 1913 were not conclusive. They found that *Dociostaurus maroccanus* Thunberg was susceptible to the disease, but the epizootic did not spread with sufficient rapidity to cause appreciable diminution in the size of the swarms. They attributed their failure to three contingencies, either the infection did not spread through the greater portion of the migrating swarm, or many of the locusts possessed a natural immunity, or else they easily acquired an active immunity against the organism.

Lounsbury in 1913 conducted experiments in South Africa to determine whether *C. acridiorum* could be effectively used in combating the non-migratory *Zonocerus elegans*. His exper-

iments were unsuccessful as the disease did not spread in the field, and he came to the conclusion that under South African conditions the biological method of d'Herelle can be used only as a supplementary measure and cannot supersede the use of poison baits in the control of locusts.

Oedaleus nigrofasciatus De Geer and *Locusta migratoroides* R. and F., two injurious locusts in the Philippines, were experimented on by Barber and Jones in 1913. An absolute failure in the field experiments was reported.

The Entomological Branch of Canada attempted without success to introduce the disease in parts of Quebec during the seasons of 1913 and 1914. Owing to the fact that the culture had to be sent a considerable distance from the laboratory in which it was prepared, which would probably affect the virulence of the organism, no definite conclusions were reached.

In 1914–15 Beguet, Musso and Sergent conducted a campaign in Algeria against an invasion of *Schistocerca peregrina* Ol. using both the biological and the mechanical methods of control. The combination of the two methods proved very successful. The biological method could not be used to protect fields that were directly menaced as the disease spread slowly. In the Sebdou region two indigenous coccabacilli were found which immunized the locusts against d'Herelle's organism. Similar organisms were reported from Algiers.

During 1915 a locust invasion of Tunisia threatened disaster over about 36,000 square miles of territory. D'Herelle succeeded in completely controlling the outbreak by means of a combination of the biological and mechanical methods.

In Morocco during 1915 Velu and Bouin conducted extensive experiments on the control of *S. peregrina.* They concluded that "d'Herelle's method gives encouraging results. Starting with a sufficiently virulent culture of the coccobacillus it is possible to create, either by spraying with bouillon or by contamination from diseased nymphs, an epizootic which is very contagious and sometimes extremely deadly, but the progress of which is by no means overwhelming." They advise its judicious combination with other methods.

The experiments described below were conducted at the request of Dr. C. Gordon Hewitt, Dominion Entomologist, during the summer of 1916. The original culture used was obtained by Dr. Hewitt from the Pasteur Institute at Paris.

B. Symptoms of the Disease.

The time elapsing between infection and the manifestation of the symptoms characteristic of the disease depends on the virulence of the organism, and may vary from a few hours to several days. Diseased locusts become sluggish and more or less paralyzed, losing to some extent the power of leaping. The excrement is black and fluid, and when the insect is dissected it is found that the contents of the digestive tract are black and more or less slimy. After death putrefaction proceeds rapidly and the integument becomes blackened.

Bacteriological or microscopical examination reveals the presence of the coccobacillus in the intestinal tract, the blood and faeces in practically pure culture.

C. Increasing the Virulence of the Organism.

It was the experience of d'Herelle and subsequent workers that the coccobacillus when grown in artificial culture media becomes very much weakened, but that the virulence could be progressively increased by passing the organism through a succession of locusts.

In order then to obtain a culture sufficiently strong for our experiments it was necessary thus to increase the virulence. The first lot of locusts was inoculated with a suspension of the original culture. On analyzing the contents of the intestines of locusts killed by this injection we obtained a pure culture of the coccobacillus. We decided then to use a suspension of the intestinal contents of the dead locusts in our further injections. Parallel with this we ran what we termed "a pure culture series," that is, a series in which the intestinal contents of the dead locusts were plated out on 1% beef peptone agar, incubated at 30° C. for eighteen hours, and then from the plates a typical colony selected and this pure culture used for inoculating the next lot. By the first method we obtained a virulent culture much sooner than by the second.

Our method of procedure was as follows: The dead locust was placed for a few minutes in alcohol. Upon removal from the alcohol its body was split along the back with a sterile pair of scissors and a portion of the digestive canal severed. The cut portion was removed with sterile forceps, dropped in a test tube containing 10 cc. of sterilized water and triturated. The suspension thus obtained was used in inocluating the healthy locusts.

The locust to be inoculated was held between the thumb and forefinger of the left hand and a drop of the suspension was injected between the first and second abdominal sternites by means of a very fine hypodermic needle.

The first lot inoculated were all dead in five days, owing doubtless to the fact that a rather strong suspension of the original pure culture was used. The second, third and fourth lots did not all die, some remaining alive for upwards of twenty-three days. After the fourth inoculation no injected locusts survived.

Some of the locusts of the second, third and fourth lots which were apparently healthy after twenty-three days were killed and the intestinal contents examined, and we found that the coccobacillus was present.

The remainder of the survivors were injected with a virulent culture and all died within a few hours.

The following table shows the increase of the virulence of the organism. The first lot in the series was inoculated with Dr. d'Herelle's culture, the others were each inoculated with a suspension of the intestinal contents of the preceding lot.

TABLE I.

SHOWING THE INCREASE IN THE VIRULENCE OF *C. acridiorum*, TEMPERATURE ABOUT 85°F

Lot	No. inoculated	Time	No. dead	Time	No. dead	Time	No. dead	Time	No. dead	Time	No. dead	Time	No. dead	Last one dead
1	12	1 day	4	2 days	6	3 days	8	4 days	9	5 days	12	......	...	5 days
2	12	8 hrs.	2	16 hrs.	5	27 hrs.	6	2 days	7	4 days	8	5 days	9	*
3	14	20 hrs.	6	27 hrs.	7	3 days	9	3$\frac{1}{3}$ da.	10	......	...	......	...	*
4	15	22 hrs.	3	16 hrs.	4	71 hrs.	5	6 days	6	......	...	......	...	*
5	15	21 hrs.	9	23 hrs.	11	28 hrs.	14	34 hrs.	15	......	...	......	...	34 hrs.
6	20	5 hrs.	1	9 hrs.	4	21 hrs.	16	27 hrs.	20	......	..	......	...	27 hrs.
7	12	6 hrs.	1	8 hrs.	6	96 hrs.	9	10 hrs.	10	11 hrs.	12	......	...	11 hrs.
8	12	15 hrs.	12	......	...	......	...	......	...	......	...	......	...	†
9	15	5 hrs.	3	7 hrs.	5	8 hrs.	12	10 hrs.	14	11 hrs.	15	......	...	11 hrs.
10	15	3 hrs.	2	8 hrs.	10	10 hrs.	14	11 hrs.	15	......	...	......	...	11 hrs.
11	12	4 hrs.	1	6 hrs.	4	8 hrs.	5	10 hrs.	8	13 hrs.	10	19 hrs.	12	between 13&19hr ‡
12	14	2 hrs.	2	7 hrs.	10	9 hrs.	14	......	...	......	...	......	...	9 hrs.

*Did not all die.

†No observation made until 15 hours after injection.

‡No observation made between the 10th and 19th hours after inoculation. The temperature on the day this lot was inoculated fell nearly 10°F., which accounts for the longer time required for death to occur.

After the twelfth lot there was little increase in virulence. Quite often several locusts would die within a very short while after being injected. This was probably due to a previously weakened condition of the locusts which rendered them less resistant to the septicæmic action of the coccobacillus. The intestinal contents of those which died thus early were not as virulent as those of the ones which died later. The following table brings out this point:

TABLE II.

COMPARISON BETWEEN THE VIRULENCE OF THE INTESTINAL CONTENTS OF LOCUSTS WHICH DIE VERY EARLY AND OF THOSE FROM THE SAME LOT WHICH DIE LATER.

Source of culture	No. inoculated	Time	No. dead	Time	No. dead	Time	No. dead	Remarks
Early killed locusts.......	12	3 hrs.	1	11 hrs.	2	24 hrs.	11	1 alive after 24 hours.
Later killed locusts.......	14	2 hrs.	2	7 hrs.	10	9 hrs.	14	All dead in 9 hours.

D. *Insects Susceptible to the Disease.*

The pathogenicity of *Coccobacillus acridiorum* was tested for all species of locusts and grasshoppers commonly occurring in large numbers in this region. These were *Melanoplus femur-rubrum, M. bivittatus, M. atlanis, Dissosteira carolina, Camnula pellucida, Stenobothrus curtipennis* and *Xiphidium sp.* All of these insects proved to be susceptible.

Gryllus pennsylvanicus, one of the common field crickets, also died as a result of injection with the coccobacillus, and several dead specimens of *Nemobius spp.* were found dead in the field, doubtless as a result of eating the infected bran mash.

Of insects other than the Orthoptera only two were tested, the yellow bear caterpillar (*Spilosoma virginica*) and the potato beetle (*Leptinotarsa decemlineata*) larvæ and adults. The caterpillars were all dead in less than forty-eight hours. The number of inoculated potato beetles and their grubs which died did not exceed the number dead in the check injected with distilled water, so we must conclude that this beetle was not susceptible to the disease.

Apparently the activities of the insect and other animal parasites of the diseased locusts were not affected. We were able to rear several sarcophagid flies from diseased locusts and a very large number of living Gordioidea emerged from the diseased or dead insects.

Other workers have tested the pathogenicity of *Coccobacillus acridiorum* for various other insects and have found that not all insects are susceptible to the disease.

D'Herelle found that chickens, guinea pigs and rabbits were not susceptible and that man apparently suffered no ill effects even when the cultures were carelessly handled.

E. Experiments in the Laboratory.

Experiments were performed in the laboratory in order that we might become acquainted with the nature and action of the disease before trying it out in the field. These experiments were all carried out in breeding cages which were sterilized before each experiment.

The number of animal parasites, chiefly nematodes, and Diptera, was exceedingly high, so it must be borne in mind that several of the deaths recorded in these experiments may have been due entirely to the parasite or to the fact that the resistance of the locusts was lowered owing to the weakening action of the animal parasites.

Deaths which did not occur within a week to ten days were considered doubtful because the percentage of deaths among the checks confined for so long a time was fairly high.

Experiment 1. Effect of Spraying the Insect with a Culture of Coccobacillus.

Ten locusts were sprayed thoroughly. One died at the end of thirty hours, a second in two days, a third in three days, and at the end of eight days there were only five dead. The others remained alive for some time showing no symptoms of disease.

Experiment 2. Effect of Contaminating the Soil.

a. Twelve locusts were placed in a breeding cage containing sand sprayed with a culture of *C. acridiorum*. One died at the end of the first day. The others remained alive for several days and showed no symptoms of disease.

b. Several locusts were placed in an unsterilized cage from which dead locusts had just been removed. No mortality was produced.

Experiment 3. Effect of Contaminating the Food of the Locusts.

a. Seventeen nymphs were placed in a cage containing green food sprayed with a culture of the organism. The food was renewed daily and for several days it was sprayed either with a pure culture of the coccobacillus or with a suspension of the intestines of dead locusts. There were no deaths until the fifth day, when one nymph died. After this there were a few deaths at intervals. The experiment was discontinued at the end of three weeks. The intestines of some of the living locusts were then examined and *C. acridiorum* was found.

b. Twenty locusts were fed with sweetened bran mash to which a culture of the coccobacillus had been added. Two died during the next day. By the seventh there were altogether twelve dead and on the eleventh day fifteen. The others survived for eight days after being removed to a clean cage.

Experiment 4. Infection from Dead or Diseased Locusts.

Experiments were tried to determine whether the disease would spread readily from dead or diseased locusts to healthy ones. To this end a number of healthy locusts were placed in a cage with others that had just died. The locusts used were largely *M. femur-rubrum* with a few individuals of other species. Nearly all the locusts failed to show symptoms of the disease.

It was observed that occasionally a *bivittatus* would feed on the dead insects. In order to determine the effect of this cannibalistic tendency on the spread of infection we placed *femur-rubrum* and *bivittatus* in equal numbers in a cage with dead locusts. At the end of eight days 80% *bivittatus* were dead and only 20% *femur-rubrum.* We have never in our experiments observed any manifestation of cannibalism in any of the forms of locusts and grasshoppers experimented on except *M. bivittatus*, and in this case the tendency to prey on the feeble individuals is not very marked.

Experiment 5. Relative Resistance of Male and Female Locusts.

We were unable to observe any difference in the resistance of male and female locusts. The following is an example which shows how similar the two sexes are in the degree of susceptibility:

TABLE III.

Sex	No. in-oculated	NUMBER DEAD IN					
		10 hrs.	12 hrs.	14 hrs.	15 hrs.	16 hrs.	20 hrs.
Female....	10	4	5	7	8	9	10
Male......	10	5	6	7	8	9	10

Experiment 6. Relative Resistance of Adult and Nymph.

It was observed during the various experiments that the nymphs apparently were more resistant than the adults. Two experiments to definitely prove this gave the results shown in the following table:

TABLE IV.

Stage	No.	NUMBER DEAD IN							Alive at end of 13 hrs.
		3 hrs.	6 hrs.	8 hrs.	9 hrs.	11 hrs.	12 hrs.	13 hrs.	
Adult.........	10	1	3	6	9	..	..	..	1
Nymph.......	10	..	..	1	2	3	4	5	5

TABLE V.

Stage	No.	NUMBER DEAD IN							
		10 hrs.	11 hrs.	12 hrs.	13 hrs.	14 hrs.	16 hrs.	18 hrs.	23 hrs.
Adult...........	10	2	5	9	10	..	..	..	..
Nymph..........	10	2	..	3	..	4	6	7	9

Experiment 6. Relative Susceptibility of Different Species.

Experiments were tried to ascertain whether there was any difference in the susceptibility of *M. femur-rubrum*, *M. bivittatus*, *D. carolina* and *S. curtipennis*. In no two experiments did the results accord, so we concluded that, as far as these four species are concerned, differences in susceptibility are individual rather than specific.

Similar results were obtained when we tried to ascertain whether any one species was more susceptible to a culture obtained from the same species or from a different species.

From the results of the foregoing experiments it is clear that *Coccobacillus acridiorum* is pathogenic to all the common injurious locusts and grasshoppers of Eastern Canada, and that these insects are equally susceptible. The immature stages of the insects are more resistant than the adult stage.

Infection does not spread readily to healthy insects by mere contact with diseased locusts or other contaminated material. The chief, if not the only method of spreading the disease, is by ingestion of infected material.

While many individuals are tolerant of a mild infection they are not totally immune because all the locusts which survived in the various experiments succumbed when re-inoculated with a strong virulent culture. Their tolerance is probably due to the presence of certain closely allied bacilli in the intestines.

F. Experiments in the Field.

Experiments in an Enclosed Area:

In order to be definitely certain of our results a small area of a lawn was enclosed with screen-wire and numerous locusts included in the enclosure.

Experiment 1.—The grass of the enclosed area was sprayed with a bouillon culture of *C. acridiorum* and daily observations made for a week. During this time not a single death was recorded. The failure of this attempt was probably due to the death of the organism as a result of its exposure to bright sunlight. As it remained very bright for some time after this the experiment was not repeated.

Experiment 2.—A new portion of the lawn was enclosed and sown with sweetened bran mash to which a bouillon culture of the organism had been added. On the second day we found 21 dead locusts, and several others showing symptoms of the disease. At the end of five days we had collected altogether 108 dead locusts. Many of the survivors were then placed in insect cages and the majority died within five days of their capture.

Experiment 3.—Twenty locusts inoculated with a virulent culture of *C. acridiorum* were introduced among the healthy locusts in another enclosed area. At the end of the fifth day only 39 dead locusts, including the inoculated ones, were found. The experiment was continued for several days but no further deaths were recorded.

Experiments in the Open Field:

Two unsuccessful attempts were made to create an epizootic centre in the open field.

Experiment 1. The first attempt was made in a clover field badly infested with *M. femur-rubrum*. A small area of this field was treated with the infected bran mash. The field was examined daily but comparatively few dead locusts and no evidences of an epizootic were found. Numbers of locusts were collected from this field and placed in insect cages but the disease did not develop among them.

Experiment 2. A similar experiment was conducted on a badly infested lawn with the same results.

G. *Conclusions.*

The results of our work indicate that d'Herelle's biological method for the control of locusts cannot take the place of the methods now in use under the conditions which obtain in Eastern Canada. Should the disease become established, its spread would be extremely slow owing to the non-migratory and non-cannibalistic habits of the native species. The ideal conditions for the effective use of this method are those such as d'Herelle and others found in South America and North Africa where the locusts were in quickly moving swarms and were markedly cannibalistic in their habits. Indeed, most of these writers have emphasized the fact that "acridiophagy" is the chief factor in the spread of the disease. Another hindrance to the effective use of this method lies in the presence of several native strains of a coccobacillus identical with or closely related to d'Herelle's. These organisms are undoubtedly responsible for the immunity of the locusts to a mild infection of *Coccobacillus acridiorum.*

PART II. DESCRIPTIVE STUDIES ON COCCOBACILLUS ACRIDIORUM D'HERELLE, AND SIXTEEN RELATED NATIVE ORGANISMS.

During the early part of our work we made plates daily from the intestinal contents of dead locusts. In every case we got a pure culture of the organism. The culture medium used was 1% beef peptone agar and the plates were kept at room temperature (about 30° C.). The growth under these conditions is rapid. The colonies are spreading and filmy and not

as sharply defined and compact as they appear in a more concentrated agar. The typical colonies appeared within ten hours and the culture was always ready for use within 18 hours.

An attempt was made to estimate the number of viable organisms found in the digestive tract of insects which had died from the disease and also of those which survived infection. As one would expect, the number of coccobacilli in the intestines of dead locusts varied between very wide limits, depending probably on the length of time elapsing between infection and death, and on the number of organisms originally injected. The number usually exceeded 100,000 and our experiments showed that this number continued to increase after the death of the host.

4 hours after inoculation, just dead, 100,000 organisms.
10 hours after inoculation, 6 hours dead, 400,000 organisms.
24 hours after inoculation, 20 hrs. dead, 5,000,000 organisms.

Locusts which survived infection gave a much lower count, as the following table shows:

TABLE VI.

NUMBER OF COCCOBACILLI IN INTESTINAL TRACT OF LOCUSTS SURVIVING INFECTION.

SOURCE OF INFECTION	NUMBER OF COCCOBACILLI
Weak culture *Coccobacillus*	150
Stronger culture *Coccobacillus*	1,600
Infected food in laboratory	1,500
Contact with dead locusts	200
Infected food in enclosed field	30,000

Viability of Coccobacillus acridiorum in Bran Mash.

If bran mash is used for the conveyance of the coccobacillus it would be important to know how long the organism will retain its virulence in the mash. To test this we placed a shallow receptacle of bran in the shade out of doors. On the first day there were 365 million coccobacilli per gram of bran mash. After four days the number was reduced to 100 million, and a few of the locusts which were fed this mash died. At the end of eight days there were 250,000 coccobacilli per gram of bran mash. Locusts injected with a pure culture of coccobacilli from the eight day old bran did not die.

Native coccobacilli isolated from the digestive tract of Locusts.

In the first part of this paper we stated that our failure was probably due in part to the immunizing effect of native strains of coccobacilli.

We have described altogether sixteen organisms, some practically identical with d'Herelle's organism, the others more or less closely related.

The first culture was obtained from an individual of *Melanoplus bivittatus* which dropped dead near one of the authors at some distance from the laboratory, before any experiments were tried in the field. This coccobacillus showed a progressive increase in virulence similar to *Coccobacillus acridiorum.*

The other cultures we obtained both from apparently healthy locusts and from diseased or dead ones. In addition to those described a few other organisms were isolated, but we have included only those which are allied to *Coccobacillus acridiorum* and which injected into the intestinal canal of locusts cause death within twenty-four hours.

TABLE VII.

SOURCE, NUMBERS, ETC., OF THE COCCOBACILLI DESCRIBED.

Culture	Source	Location	Total No. of organisms	Coccobacilli	Other organisms
3	M. femur rubrum (healthy)	Montreal Island	4,000	4,000	......
5	D. carolina (healthy)	"	7,000	7,000	......
13 & 14	M.femur-rubrum "	"	1,400	1,400	......
12	" " "	"	4,400	4,400	......
15	" " "	"	3,500	3,000	500
6	M. bivittatus "	"	6,800	6,750	50
10	D. carolina "	Islet in Lake St. Louis	7,000	7,000	......
11	S. curtipennis "	"	840	840	......
8	M.femur-rubrum "	"	560	560	a few developed later
17	" " "	Mainland	4,400	4,400	......
7	D. carolina (dead)	Montreal Island	600,000	600,000	......
2	M. bivittatus (dead)	"	200,000	200,000	......
4	" (diseased)	"	60,000	60,000	......
16	" (parasitized by maggot)	"	200	60	180

We include below d'Herelle's original description as well as a fuller description by ourselves of the culture received from the Pasteur Institute. For convenience the organisms are divided into four groups. The first group includes *C. acridiorum* and those native coccobacilli which are practically identical with it; the second and third groups include strains which differ in several details, and the fourth group includes two organisms which differ chiefly in the fact that they are able to liquefy gelatine.

Coccobacillus Acridiorum d'Herelle.

Original Description by d'Herelle.

Morphology. Short bacillus, slightly oval, polymorphous. Cocci 0.6μ, bacilli 0.4μ–0.6μ by 0.9μ–1.5μ. Very motile. Flagella peritrichiate. Stains easily. Gram negative.
Agar Stroke. Not mentioned.
Potato. Growth abundant, creamy. Condensation water, syrupy and strongly alkaline.
Gelatine Stab. Not mentioned.
Nutrient Broth. Turbidity apparent after 4 hours, no sediment, clearing after 3 weeks with slight sediment, odor of beef extract.
Milk. Coagulated, strong alkaline reaction.
Litmus Milk. Not mentioned.
Gelatine colonies. No liquefaction.
Agar colonies. Circular in shape, waxy, visible after 12 hours, 18 hours, 3 mm. diameter. *Below surface* small, spherical, whitish opaque.
Aesculin agar. Not mentioned.
Fermentation of Sugars. +glucose, levulose, galactose, maltose. No other sugars mentioned.
Indol. Not mentioned.
Neutral red bilesalt Agar. Not mentioned.
Pathogenicity. Pathogenic to various Acrididæ, ants and caterpillars.

GROUP I.

Culture of C. acridiorum from Pasteur Institute, and Cultures 6, 7, 13 and 14.

Morphology. From agar slope 20 hours old, short rods or cocci, some oval, polymorphous. 0.7μ–1.0μ. In milk culture they appear often as diplococci. Motile. Gram—. Amylgram+. Stain readily.
Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white to bluish white, opaque, butyrous, medium unchanged. On 1% agar the cultures are arborescent and transparent.
Potato. Abundant growth, spreading, flat, glistening, smooth, butyrous; color from dirty white to yellow.
Gelatine Stab. Uniform growth, line of puncture filiform. No liquefaction, medium unchanged. Stab brownish yellow.
Nutrient Broth. Pellicle or ring, turbidity, slight sediment, no clearing after 14 days, odor of beef extract.
Milk. At first gas production without coagulation. Delayed coagulation in 2–8 days, acid reaction after 8 days, no peptonisation, medium unchanged, no extrusion of whey.
Litmus Milk. Gas production, weak acidity, no reduction. After 4 days partial to complete coagulation, acid.
Gelatine Colonies. Growth slow, round, raised, edge entire, yellow. 3 weeks, 2 mm. diameter, yellow white. No liquefaction.

Agar colonies. Rapid growth, irregular, round, smooth, flat, edge entire, amorphous, dirty white to blue transparent. Growth more restricted on 1½% than on 1% agar.

Aesculin bilesalt agar. C. acridiorum weak field after 24 to 48 hrs. Cultures 6, 7 and 13 typical black field after 24 hrs., greatly increased in intensity after 48 hrs. Culture, 14, no field after 24 hrs., very intense black field after 48 hrs.

Fermentation of sugars. +glucose, galactose, muscle sugar, lactose (weak). —adonit, dulcit.

Differences are observed in the following sugars:

	C. Acrid.	Cult.6	7	13	14
Saccharose........................	+	+	+	+	—
Rafinose..........................	+	+	+	+	—
Arabinose.........................	+	—	—	+	+

Indol reaction. Negative.

Neutral red bilesalt agar. C. acridiorum strong fluorescence, red, spreading.
Culture 6, strong fluorescence, canary yellow, spreading.
Culture 7, strong fluorescence, canary yellow.
Culture 13, strong fluorescence, canary yellow, red ring, spreading.
Culture 14, strong fluorescence, canary yellow, red ring, spreading.

Pathogenicity. Pathogenic to locusts and grasshoppers. Injection fatal within 24 hours.

GROUP II.

Cultures 4, 10, 12, 20.

Morphology. From agar slope 20 hrs. old. Short rods or cocci, polymorphous. 0.7μ–1.0μ. In milk culture they appear as micrococci or diplococci. Decidedly motile. Gram –. Amylgram+, except Culture 12, which is negative. Stain easily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white to bluish white, opaque, butyrous, medium unchanged. On 1% agar the cultures are arborescent and transparent.

Potato. Growth abundant, spreading, flat, glistening, smooth, butyrous, color from dirty white to deep yellow. Culture 12 has a drier growth than the other cultures.

Gelatine Stab. Growth uniform, line of puncture filiform, of a yellow brown color, no liquefaction, medium unchanged. Culture 20 started to branch after 14 days, the stab was white in color.

Nutrient broth. Culture 4, Pellicle, turbidity, sediment, no clearing after 14 days.
Culture 10, Ring, turbidity, sediment. Clearing after 48 hrs., odor of beef extract.
Culture 12, Ring, turbidity, no sediment, no clearing, after 14 days but slight sediment.
Culture 20, Turbidity, sediment, no clearing.

Milk. Gas production without coagulation. Delayed coagulation in 3 days, except in case of Culture 10, which did not coagulate at all, acid reaction, no peptonisation, medium unchanged, no extrusion of whey.

Litmus Milk. Gas production with weak acidity, no reduction. After 4 days acid and complete coagulation except Culture 10, which remained neutral to slightly alkaline and liquid.

Gelatine colonies. Culture 4, growth moderate, brownish white, round, convex, entire, no liquefaction, size 1 mm.

Culture 10, heavy growth, bright yellow, round, convex, entire, no liquefaction, 1 mm.

Culture 12, very slow growth, white punctiform, no liquefaction.

Culture 20, slow growth, bluish white, punctiform, no liquefaction.

Agar colonies. Rapid growth, round, flat, edge entire, internal structure amorphous, blue transparent.

Aesculin agar. Culture 4, decided black field after 24 hours; very strong after 48 hours.

Culture 10, no growth 24 hours, slight growth, weak field 48 hours.

Culture 12, decided field after 24 hours, very strong after 48 hours.

Culture 20, no field after 48 hours, good growth.

Fermentation of sugars. —dulcit, raffinose.
+saccharose, glucose, lactose, muscle sugar, galactose.
Culture 10 in general causes very little fermentation, only traces in saccharose and glucose.

Differences are shown—

	4	10	12	20
Adonit	+	—	+	—
Arabinose	+	—	—	+

Indol reaction. Negative.

Neutral red bilesalt agar. Culture 4, fluorescence, canary yellow, slightly spreading.
Culture 10, slight fluorescence, canary yellow.
Culture 12, strong fluorescence, canary yellow.
Culture 20, canary yellow, red ring.

Pathogenicity. Pathogenic to locusts. Death by injection occurs within 24 hours.

GROUP III.

Cultures 2, 3, 5, 15, 16, 17.

Morphology. From agar slope 20 hrs. old. Short rods or cocci, polymorphous. 1.5μ–0.9μ. In Milk culture they appear as small or large micrococci. Very motile. Gram—. Amyl gram, cultures 2, 5, 15, 17 negative, cultures 3, 16+. Stain easily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white, opaque, butyrous, medium unchanged. On 1% agar cultures are aborescent and transparent.

Potato. Cultures 2 and 17 growth abundant, spreading, flat, glistening, smooth, dry and brittle, yellow color. Cultures 3, 5, 15 and 16 abundant growth, spreading, flat, glistening, smooth, butyrous, dirty white to yellow.

Gelatine stab. Growth uniform, line of puncture filiform, of a yellow brown color, no liquefaction, medium unchanged.

Nutrient Broth. Pellicle or ring, turbidity, no clearing after 14 days, slight sediment, strong odor of beef extract.

Milk. Gas production without coagulation. Delayed coagulation except Culture 17, liquid and acid after 8 days.

Litmus Milk. Gas production with weak acidity. Cultures 5, 16 and 17 complete reduction; Cultures 2, 3, 15 no reduction. Cultures 2, 5, 16, 17 coagulation within 4 days; Cultures 3 and 15 no coagulation, acidity in Culture 3, neutral reaction in Culture 15.

Gelatine Colonies. Cultures 2, 3 and 5 slight growth, punctiform, white, no liquefaction. Cultures 15, 16 and 17 good growth, size 2 mm., bright yellow, round, convex, entire, no liquefaction.

Agar colonies. Rapid growth, round, flat, edge entire, internal structure amorphous, blue transparent, below surface small, spherical, whitish, opaque.

Aesculin agar. Culture 2 negative, Culture 15 no growth, Cultures 3, 16 and 17 positive, Culture 5 very weak.

Fermentation of sugars. +galactose.

	' lonit	Dulcit	Raffinose	Arabinose	Muscle sugar	Saccharose	Lactose	Glucose
Culture 2	—	+	—	+	+	+	+	+
Culture 3	+	+	+	+	+	- -	+	?
Culture 5	—	—	—	+	—	+	+	+
Culture 15	—	—	—	—	—	+	—	?
Culture 16	- -	—	?	+	+	+	+	+
Culture 17	—	?	—	+?	+	+	+	?+

Indol reaction. Cultures 2 and 3 very strong. Cultures 5, 15, 16, 17 negative.

Neutral red bilesalt agar. Cultures 2 and 3, red.
Culture 5, fluorescence, canary yellow, spreading.
Cultures 15 and 17, fluorescence, canary yellow.
Culture 16, canary yellow, red ring.

Pathogenicity. Pathogenic to locusts and grasshoppers. Death by injection within 24 hours.

GROUP IV.

Cultures 8 and 11.

This group shows much resemblance to Group III, but its ability to liquefy gelatine made it necessary to separate the two groups.

Morphology. From agar slope 20 hrs. old, short bacillus, slightly oval, polymorphous, 0.5μ–1.0μ. Very motile. Gram—. Amyl gram+. Stain easily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white, opaque, butyrous, medium unchanged. Arborescent on 1% agar.

Potato. Growth abundant, spreading, flat, dull, smooth, butyrous, white.

Gelatine Stab. Growth rapid, liquefaction along puncture, on top saucer shape after 24 hours, completely liquefied in 7 days.

Nutrient broth. Culture 8 pellicle, turbidity, sediment, strong odor of beef extract. Culture 11, ring, turbidity, strong odor of beef extract. No clearing after 14 days.

Milk. Coagulation prompt, strong acid and gas, no extrusion of whey, medium unchanged.

Litmus Milk. Acid coagulation, no reduction, slow peptonisation.

Gelatine colonies. Complete liquefaction within 24 hours.

Agar colonies. Rapid growth, round, smooth, flat, edge entire, amorphous.

Aesculin agar. Negative.

Fermentation of Sugars. Negative. —Adonit, dulcite, galactose, arabinose, muscle sugar, lactose, raffinose. Weak, saccharose, glucose.

Indol reaction. Weak.

Neutral red bilesalt agar. Strong fluorescence, canary yellow.

Pathogenicity. Pathogenic to locusts. Death occurs within 24 hours of injection.

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THE CHORDOTONAL ORGANS AND PLEURAL DISCS OF CERAMBYCID LARVAE.*

WALTER N. HESS.

INTRODUCTION.

For years systematists who have attempted the classification of certain coleopterous larvæ, have been perplexed by the peculiar and varied structures on the abdominal pleural region. These often take the form of a ray-like disc in the larger species, while in the smaller species, a small elliptical enlargement is present in this region. Many larvæ, even among the Coleoptera, do not possess the characters in question, but they seem to be universally present among the Cerambycids. Moreover, they are often much modified in the different genera.

During the summer of 1914, Dr. W. A. Riley, of this department, found these peculiar pleural structures on various larvæ. About the same time Mr. F. C. Craighead, of the Department of Entomology at Washington, wrote Dr. Riley asking about their functions. It was at this time that the writer undertook a study of their structure.

The writer is sincerely indebted to Mr. Craighead for mounts of these structures which he had turned over to Dr. Riley, also to Dr. Riley himself for much valuable advice and assistance.

In some larvæ, especially the larger species of Prionids, these structures are very pronounced, and instances have been known of students mistaking them for spiracles.

References in the literature are practically limited to a brief mention by Perris (1877). This writer spoke of them in the Cerambycids as "accessory locomotor organs." However, this interpretation was not accepted by Craighead (1915), who refers to them by the non-committal name of "pleural discs."

It will be shown in this paper that these external characters are not constant in all genera of the Cerambycids, that in spite of an external variation, the internal condition is usually constant, and finally, that the pleural discs are the points of attachment of abdominal chordotonal organs. The detailed structure of the latter will be described.

*Contribution from the Entomological Laboratory of Cornell University.

MATERIALS AND METHODS.

Although the histological investigation of this problem was limited to two species, *Ergates spiculatus* Lec. and *Monohammus confusor* Kirby, larvæ of other genera were examined to determine the presence and arrangement of the organs. Among these larvæ were specimens of *Saperda candida* Fabr., *Rhagium lineatum* Oliv., *Desmocerus palliatus* Forst., and *Mallodon dasystomus* Say.

In dissecting out the structure for toto preparations, best results were obtained by opening the larvæ on the mid dorsal line, and pinning them open in a watch crystal which had been half filled with paraffin. As a dissecting medium, picric alcohol was very satisfactory. In addition, Delafield's hæmatoxylin was frequently used to aid in differentiating the tissues for gross dissection. For mounts of the entire organ, staining with borax carmine was very satisfactory. Portions for sectioning were obtained from the fresh larvæ by cutting out the parts in each segment which contained the organs, and placing these directly into fixing fluids.

The parts for histological study were fixed in strong Flemming's solution for twenty-four hours, washed thoroughly, and dehydrated by the usual process. However, formol-chromic acid, as used by Schwabe, was found very satisfactory for fixing these organs. The material was infiltered in 54° paraffin for three hours, then in 58° paraffin for one hour, and imbedded. Sections were cut two, three, four, and five microns thick. For the study of cross sections, those cut two and three microns thick were more satisfactory, but for longitudinal sections, those cut at five microns were best, as it was very difficult to obtain thinner sections that showed the internal structures. For staining, Heidenhain's iron hæmatoxylin was found the most satisfactory.

LITERATURE.

Before taking up the description of these structures, we shall discuss briefly the more important work that has been done upon the chordotonal organs in insects. It is very probable that more has been written on these structures in the adult Orthoptera than in all the other insects together. Although many authors have described these organs in the insects of other orders, very little attention has been given to their condition in the larvæ.

According to Graber, details of the auditory organ of insects were first described by John Müller (1826). Müller discovered a structure in the tympanum of the Acrididæ, which he described as an elongated bubble filled with water, one end fastened to the tympanic membrane, the other end extending in the opposite direction.

Siebold (1844) found in the fore tibia of the Locustidæ, a ganglion-like body which ended in the form of a band at the side of a large trachea, and which was composed of rod-shaped little bodies. Some later writers attribute the discovery of the auditory nerve end-organ, or scolopophore, to this worker.

Leydig (1851) found in the larva of *Corethra plumicornis*, nerve endings which were located in the segments of the abdomen. They were attached at each end to the skin, and stretched lengthwise across the clear space located between the body wall and the muscles. In 1860 Leydig farther investigated the adults and larvæ of Diptera and Coleoptera, and demonstrated the peculiar nerve end apparatus. He described these structures, in the antennæ, halteres, and wings, but did no farther work on the abdominal organs. His is the first clear description we find of these nerve end bodies, and as a result Leydig is given credit for discovering them.

Weismann (1866) found in *Corethra plumicornis*, little nerve endings which he called "cords of hearing." He maintained that this hearing cord was very suitable to be set into vibration by sound waves.

Hensen (1866) showed that in the Locustidæ, the nerve fibers of the auditory nerve join the auditory rod or scolopale. Schmidt (1875) largely confirmed the work of Hensen, but discovered that the nerve fiber extended from a basal ganglion cell into the scolopale.

Although the workers mentioned above contributed considerable to our knowledge of these sense organs, the work of Graber (1881–82) laid the foundation for all future work. This worker called chordotonal, all organs that had nerve endings similar to those of the previously described auditory rods of the Orthoptera, and maintained that such organs serve an auditory function. He supported this view by showing that chordotonal organs in the various orders of insects all contain peg-like bodies or scolopalæ, such as are found in the tympanal organs of the Orthoptera.

Graber discovered that chordotonal organs are seldom, if ever, found singly, but usually in groups of two to two hundred or more to a system. He discovered that they are located between two immovable points, usually near the body-wall, free from the movements of the inner organs.

He found them in various species of Orthoptera, Neuoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera. They were not always in the same region of the body, but rather often variously located in the different groups. He observed them in the segments of the abdomen, in the antennæ of larvæ, in the legs and tarsi, in the halteres, in fore wings and the subcostal veins of hind wings. His extended observations led him to believe that the whole integument of insects, like the tympanum of vertebrates, is especially suited to be set into vibration by sounds, and that the nervous structures united to them can react to different sound waves.

Of the larvæ in which Graber reported finding these structures were: Dytiscus among the Coleoptera; Tabanus, Chironomus, Tanypus, and Syrphus among the Diptera; and Nematus among the Hymenoptera. His descriptions of these larval structures are very suggestive of what I have found in the abdomen of the Cerambycids.

From his rather extensive study of widely separated forms, Graber concluded that these organs, though often different in shape, were all alike in essential details. He noticed that the nerve end-organ had three nuclei, but it remained for a later worker to discover the exact relation between the parts of the structure itself.

Schwabe (1906) in his work on the Locustidæ, first showed that the nerve end-organ or scolopophore is composed of three cells with definite cell boundaries. These are: a cap cell, which is often elongated and attached to the body wall; a central portion or enveloping cell; and the sense cell which bears the nerve.

Schwabe's results have been largely confirmed by Schon (1910), Vogel (1912), and Lehr (1914).

THE PLEURAL DISCS OF CERAMBYCID LARVÆ.

We have already seen that the pleural discs of cerambycid larvæ are the outward expression of chordotonal organs. Since these external structures of various larvæ are being used as systematic characters, we will consider briefly their arrangement and relation in the different genera. In many species of the Prionids, such as *Mallodon dasystomus*, we find a condition such as is shown in Fig. 1, in which there is a pair of definite ray-like structures on the pleural region of each of the first six abdominal segments. These constitute the pleural discs (pl. disc) strictly speaking. On the seventh and eighth abdominal segments they are present, though somewhat modified. Instead of a simple ray-like structure, we find here an elliptical enlargement which Craighead calls the "Pleural tubercle" (Pl. Tu.). At the posterio-dorsal side of this tubercle, the pleural disc can be faintly seen (pl. disc). This ray-like structure or pleural disc, has a small median depression, at the central point of which a chitinous cap usually projects for a short distance. From this median depression, there radiate folds in the body wall, producing the previously described ray-like appearance. In addition to these ray-like folds, one often finds at the edge of the disc, folds which run perpendicularly to the rays.

Some of the smaller species of Prionids show the pleural discs only faintly, and then usually best on the first three abdominal segments. However, if one looks carefully, the others may also be found.

Outside of the sub-family Prioninæ, all the species which the writer was able to observe, possessed the elliptical or pleural tubercle. In *Saperda candida*, *Rhagium lineatum*, and *Desmocerus palliatus*, the elliptical enlargements were found on each of the first eight abdominal segments, with a faint evidence of a disc at the posterio-dorsal portion of each tubercle. In many species a slight indication of a disc was also found at the anterio-ventral end of the tubercle.

In *Monohammus confusor* a very peculiar condition was observed. The elliptical enlargement or pleural tubercle was present, but instead of a ray-like structure, or pleural disc, at either end there was found a depression in the form of a chit-

inous invagination, at both the posterio-dorsal and anterio-ventral ends, as shown in Figs. 2 and 4 (C. Inv.). Instead of opening directly laterally, the pockets open at an angle of about 45 degrees directed away from the pleural tubercle.

THE CHORDOTONAL ORGAN.

On examining the larvæ internally, one finds in the case of the Prionids with the pleural discs, that a peculiar structure in the form of a chordotonal ligament is attached at the central point of the disc, and stretched in an anterio-ventral direction across an irregularly shaped enlargement on the pleural zone, and attached at the other end to a fold in the body wall, as is shown in Fig. 5 (Ch. L.). This ligament is very slender for its posterior two-thirds, but soon thickens towards its anterior third, to two or three times the size of the posterior portion. At about one-half the distance between the beginning of this swelling and the anterior attachment, a branch of the first nerve of the corresponding segment enters the structure from the side. This is the chordotonal nerve (Ch. N.). Anterior to the entrance of the nerve, the structure narrows slightly until it attaches. In the case of the organs in the seventh and eighth abdominal segments, the condition is slightly different in that the anterior attachment is at the anterio-ventral end of the pleural tubercle, instead of on an anterior body fold as in the other six pairs. This latter condition exists in all eight of the abdominal segments of such species as *Saperda candida, Rhagium lineatum,* and *Desmocerus palliatus.* The fact that the ligament attaches anteriorly at the anterio-ventral portion of the pleural tubercle often causes a faint external evidence of a pleural disc in this region.

In *Monohammus confusor*, the condition is much the same except that at each end of the pleural tubercle, there is a large chitinous invagination (Figs. 2 and 4, C. Inv.) which projects into the body for a short distance. A chordotonal ligament similar to the one described above, is stretched across the ends of these chitinous structures (Fig. 6, Ch. L.).

STRUCTURE OF THE NERVE END ORGAN OR SCOLOPOPHORE.

In the two species, *Ergates spiculatus* Lec. and *Monohammus confusor* Kirby, which were studied for their histological structure, there was found a pair of chordotonal ligaments in each of the first eight abdominal segments. Since these organs were alike structurally, a description of one will suffice for both species. Sections were cut of these ligaments in the different abdominal segments of these two species, and also of *Mallodon dasystomus* Say, and it was found in every case, that each of the eight pairs of cords contained four nerve end organs or scolopophores.

The scolopophores of the cerambycid larvæ correspond in general to those of other orders of insects, and are especially similar to those described by Schwabe (1906). Each is a nerve end organ, composed of a ganglion cell, and two enveloping cells. The ganglion cell or, better, the sense cell, is elongated and covered on its distal end by two enveloping cells, forming a sack-like structure about the distal end of this cell. The distal one of these two enveloping cells serves to unite the end organ with the hypodermis, and is called the cap cell. (Figs. 7 and 8, C. C.). The other one of the two cells (E. C.) lies between the cap cell and the enlarged portion of the sense cell, while proximad to this cell is found the body of the sense cell (S. C.), with its continuation to the nerve (Ch. N.).

The sense cell (Figs. 7, 8 and 9, S. C.), which contains the axis fiber (Fig. 9, A. F.), is of the bipolar nerve type, continuous proximad with the chordotonal nerve (Ch. N.). Its distal portion penetrates the center of the enveloping cell into the proximal end of the cap cell, where the nerve enlarges to form the peg-shaped body or scolopale (Sc.). The cell enlarges in its middle portion, in which region is found a large spherical shaped nucleus, containing large and fine chromatin parts. The cytoplasmic structure is similar to that of other nerve tissues. An axis fiber runs nearly straight through the sense cell, except where it bends around the large nucleus. As it enters the proximal end of the cell, it is very small, but as it approaches the distal end, it gradually becomes much enlarged. However, at the point where it enters the peg-shaped body, or scolopale,

it again becomes very small, and continues as a fine cord until it joins a knob-shaped structure near the apex (the end knob Fig. 9, E. K.).

In the larvæ under consideration, these peg-shaped bodies, or scolopalæ, were found located near together with their distal ends in the region where the thickened portion of the chordotonal ligament begins to taper posteriorly. In this rather narrow region is located the distal end of the posterior of the four scolopalæ, and the other three are arranged in a series anteriorly, so that no two of the four organs are the same distance from the posterior end. These scolopalæ are considered by most authors as the enlarged terminal portions of the axis fibers. However, Schwabe is not of this opinion but considers each as a cap-like enveloping apparatus itself. With this latter interpretation my results do not accord.

In general, the scolopalæ in *Ergates spiculatus* are very much like the ones which Schwabe described for the Orthoptera. At the base of each is a vacuole (Fig. 9, V.) which connects with the hollow central portion and, according to Schwabe, is filled with a watery fluid. The number of outer strands or ribs (Fig. 10 B., R.) of which the scolopale is composed, is different from what Schwabe found, in that there are seven large basal strands which divide a little over one-third their distance distally, making a total of fourteen (Fig. 10 C., R.). The dark cap, or knob, located in the distal portion of the scolopale was found to be composed of seven large, opaque divisions, corresponding to the seven basal parts. (Fig. 10 D., E. K.). However, the exact relation between these and the fourteen ribs could not be determined, though it seems very probable that the ribs pass along the exterior portion of the knob, and form the terminal ligament (Fig. 10 A., T. L.), which extends into the cap cell for about one-fourth the length of this cell. The entire scolopale, except possibly the terminal ligament, is bathed in the watery liquid, and is free to vibrate.

The enveloping cell is a rather large, elongated cell, which lies like a funnel over the greater part of the distal end of the sense cell (Fig. 9, E. C.). It is composed of a light, nearly transparent, alveolar, cytoplasmic structure, with an enlarged nucleus (E. C. N.) towards its proximal end.

The cap cell is located distad of the enveloping cell, and connects it with the body wall (Figs. 7 and 8, C. C.). It contains at its base the distal end of the sense cell, with its scolopale. Structurally, the protoplasm of this cell is of a much denser nature than that of either of the other two cells, but about its proximal portion the protoplasm is not as dense as farther distad. The whole cell is more or less filled with dark staining strands, or fibrils (F.), which pass in a rather winding condition, somewhat as the strands of a rope, to the distal end, where they unite directly to the cuticula (C. C. A.). This cell is exceptionally long and spindle-shaped and, as Weismann suggested, it seems very capable of vibrating. Near its proximal end is a small elliptical nucleus (C. C. N.), containing dark areas of chromatin.

The portion of the chordotonal ligament anterior to the enveloping cells, and at the sides of the sense cells, is composed of a substance which Schwabe called the "fibrillar binding substance." (Figs. 7, and 8, B. S.). This structure begins to appear in the region of the proximal part of the enveloping cells, and continues along the sides of the sense cells to the anterior attachment. It contains many nuclei, but in no case were cell boundaries seen. These fibrillar strands with their nuclei finally occupy the entire cord at its anterior portion, and by means of these fibrils the cord is fastened directly to the cuticula, much in the same way as at the posterior end. Schwabe regards this fibrillar binding substance as a continuation of the covering of the nerve. This idea seems quite plausible from the appearance of this substance about the sense cells. However, when one considers the character of the fibrils, the nuclei, and the method of attachment, it may be interpreted as a separate modified hypodermal structure.

All larvæ that were studied possessed eight pairs of these abdominal organs. The ones at the anterior part of the abdomen were one-fourth to one-half a millimeter longer than those in the posterior segments, while the others formed a proportional gradation in between.

Since the four nerve endings of each cord are so arranged that no two are the same distance from the posterior attachment, it seems very evident that there is a possibility that the larva is able to detect sounds of different wave lengths.

Authors disagree regarding the function of these organs. Graber ('82), Schwabe ('06), Schon ('10), and many others regard them as organs of hearing, but some of the more recent writers, such as Radl ('05) maintain that they have a static function.

No muscles were found which appeared to function in regulating the length of the ligaments, and it seems, so far as could be discerned, that the length is constant. In the Corethra larva these ligaments have been observed to shorten and lengthen in the living animal, but from a study of the chordotonal ligaments in the wood-boring Cerambycid larvæ, it does not seem possible that their length is changeable.

The external covering of the chordotonal ligament is rather thick, due largely to the fact that the basement membrane which covers the hypodermis internally, also forms a covering about this structure.

What relation the tracheal system has to these organs is not certain. Schwabe ('06) found enlarged tracheal sacks in the region of the organs in the Orthoptera. Vogel ('12) found a corresponding relation between the chordotonal organs in the wings of butterflies and the trachea. Lehr ('14) found a similar condition in the wings of *Dystiscus marginalis*. In the abdomen of the forms here studied, a rather large trachea was always observed in close-apposition to that part of the chordotonal ligaments which contained the peg-shaped bodies or scolopalæ.

The cuticula at the posterior point of attachment of the chordotonal ligaments in all species studied, and at both ends in *Monohammus confusor*, was found modified into a very hard, dark-staining structure. This condition, together with the arrangement of the scolopalæ in the ligaments, seems to favor the idea that the organs are for hearing, rather than for balancing, since sound waves could easily be transferred by this hardened cuticula to the ligament, which by its vibration, could carry the impulse to the nerve and organ.

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EXPLANATION OF PLATES.

PLATE IV.

Fig. 1. Lateral view of the larva of ***Mallodon dasystomus*** Say. Amb Amp, Ambulatory ampulla; Hy P, hypopleurum; in seg, intersegmental area; pl disc, pleural disc; Pl Tu, pleural tubercle; Pl Z, pleural zone; Pnot, pronotum; P. Scl, postscutellum; S, spiracle; Sp A, spiracular area.

Fig. 2. Lateral view of the larva of ***Monohammus confusor*** Kirby. Amb Amp, Ambulatory ampulla; C Inv, chitinous invagination; Hy P, hypopleurum; Pl Tu, pleural tubercle; Pnot, pronotum; S, spiracle.

Fig. 3. Enlarged pleural disc of the first abdominal segment of ***Mallodon dasystomus*** Say. C Pl, center of pleural disc, with chitinous cap; R Pl, ridge of pleural disc.

Fig. 4. Pleural tubercle of the sixth abdominal segment of ***Monohammus confusor*** Kirby. C Inv, chitinous invagination; Pl Tu, pleural tubercle; Se, seta.

PLATE V.

Fig. 5. Left side of the third abdominal segment of ***Ergates spiculatus*** opened from the dorsal side. A A , anterior attachment of chordotonal ligament; Ch L, chordotonal ligament; Ch N, chordotonal nerve; G Cn, ganglion of central nervous system; Hy P, hypopleurum; in seg, intersegmental area; N, nerve; P A, posterior attachment of chordotonal ligament; Pl Z, pleural zone; S, spiracle.

Fig. 6. Left side of the sixth abdominal segment of ***Monohammus confusor*** Kirby, opened from the dorsal side. A A, anterior attachment of chordotonal ligament; Ch L, chordotonal ligament; Ch N, chordotonal nerve; C Inv, chitinous invagination; G Cn, ganglion of central nervous system; Hy P, hypopleurum; in seg, intersegmental area; N, nerve; P A, posterior attachment of chordotonal ligament; Pl Tu, pleural tubercle; Pl Z, pleural zone; S, spiracle.

PLATE VI.

Fig. 7. Longitudinal vertical section of the pleural tubercle and chordotonal ligament of ***Monohammus confusor*** showing two scolopophores. A B S, attachment of binding substance, at anterior end; B S, binding substance; B S N, binding substance nucleus; C C, cap cell; C C A, cap sell attachment, at anterior end; C C N, cap cell nucleus; Ch N, chordotonal nerve; C Inv, chitinous invagination; E C, enveloping cell; E C N, enveloping cell nucleus; E K, end knob; F, fibrils of cap cell; Hyp, hypodermis; M C, modified cuticula; P C, primary cuticula; S C_1, secondary cuticula; S C, sense cell; Sc, scolopale; S. C. N, sense cell nucleus; T L, terminal ligament; V, vacuole.

Fig. 8. Longitudinal vertical section of the pleural zone and chordotonal ligament of ***Ergates spiculatus*** showing two scolopophores; A B S, attachment of binding substance, at anterior end; B S, binding substance; B S N, binding substance nucleus; C C, cap cell; C, chitinous cap; C C N, cap cell nucleus; Ch N, chordotonal nerve; E C, enveloping cell; E C N, enveloping cell nucleus; E K, end knob; F, fibrils of cap cell; Hyp, hypodermis; M C, modified cuticula; P C, primary cuticula; S C_1, secondary cuticula; S C, sense cell; Sc, scolopale; S C N, sense cell nucleus; T L, terminal ligament; V, vacuole.

PLATE VII.

Fig. 9. Enlarged portion of scolopophore. A F, axis fiber; C C, cap cell; C C N, cap cell nucleus; E C, enveloping cell; E C N, enveloping cell nucleus; E K, end knob; F, fibrils of cap cell; Sc, scolopale; S C, sense cell; S C N, sense cell nucleus; T L, terminal ligament; V, vacuole.

Fig. 10. *A* is an enlarged peg shaped body or scolopale with portions of the three cells of the scolopophore. *B* is a cross-section in the region of the proximal portion of the scolopale. *C* is a cross section in the region of the center of the scolopale. *D* is a cross-section in the region of the end knob. A F, axis fiber; C C, cap cell; D S C, distal portion of sense cell; E C, enveloping cell; E K, end knob; F, fibrils of cap cell; Sc, scolopale; R, rib of scolopale; T L, terminal ligament; V, vacuole.

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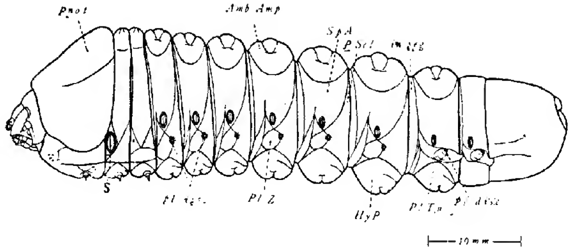

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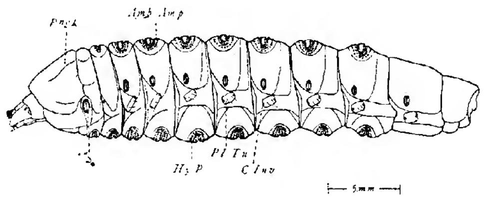

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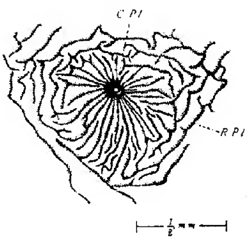

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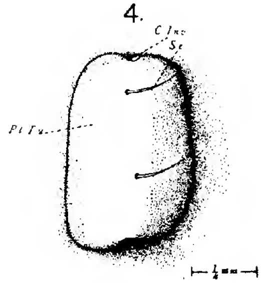

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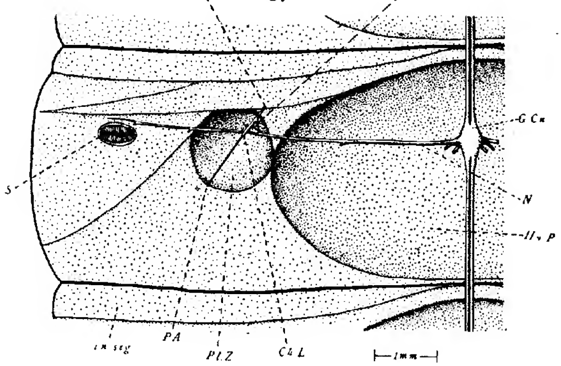
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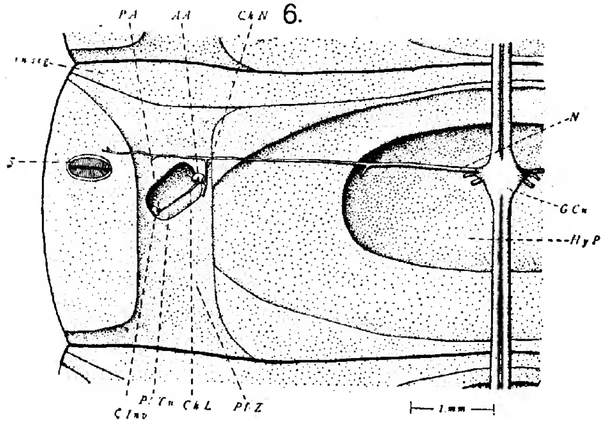
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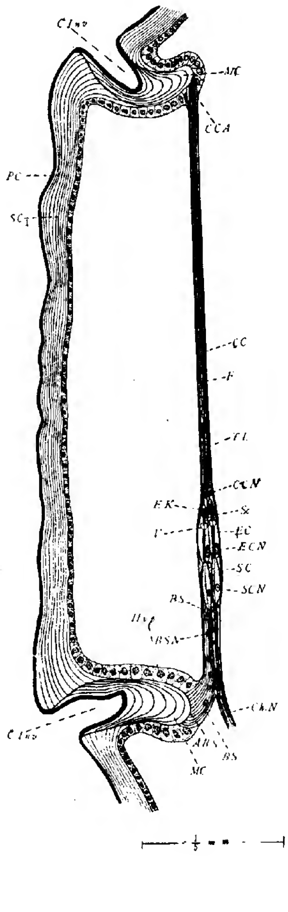

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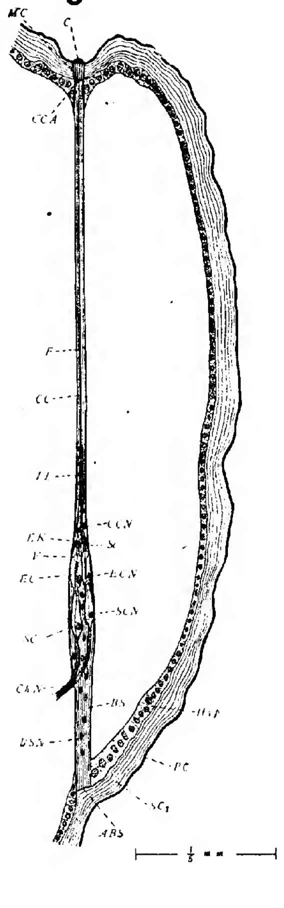

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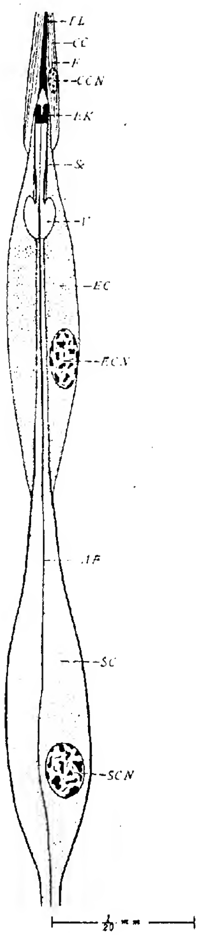
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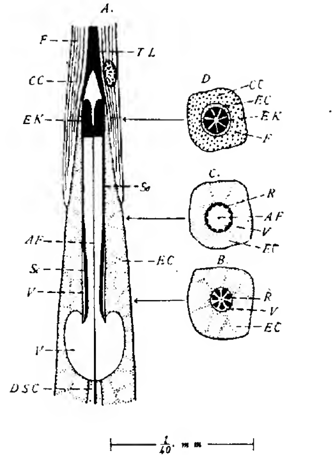
10.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DSC
1/40 mm

W. N. Hess.

THE CICADELLIDÆ (JASSOIDEA-FAM. HOMOPTERA) OF WISCONSIN, WITH DESCRIPTION OF NEW SPECIES.

(With Two Plates).

By J. G. SANDERS, Harrisburg, Pa.

and

D. M. DELONG, O. S. U., Columbus, Ohio.

Interesting facts are always brought forth, when comparisons are made of faunal groups of several states. The insect fauna of Wisconsin has received but little attention in the past, because of a lack of entomological work of any considerable range in that state. For this reason it was not surprising that thirteen distinct species new to science were found in the limited group formerly known as the superfamily Jassoidea, but lately changed by Mr. E. P. Van Duzee in his list* to Cicadellidæ.

The Cicadellid faunas of four states east of the Mississippi river have been fairly well determined, viz.: Maine, New York, Tennessee and Wisconsin, and the following table shows at a glance the relative abundance of species of several genera in these regions.

	WIS.	MAINE	N. Y.	TENN.
Cicadellinæ	20	12	21	27
Bythoscopinæ	26	27	31	13
Deltocephalus	26	15	14	25
Euscelis	14	12	11	7
Phelpsius	14	9	10	19
Thamnotettix	17	16	12	11
Chlorotettix	6	4	6	15

The collection of material in this group has been carried on since 1910 by the senior author, but the larger part of the material was collected during the summer of 1916 by both authors, while traveling over the state in nursery inspection

*Check List of Hemiptera of Amer. N. of Mexico, New York Ent. Soc., 1916.

work. The list as determined numbers 206 species and varieties, representing 38 genera, and is second in number of species to the Tennessee list containing 212 species, which was published last year by the junior author.

In Maine, a state with a similar location and having a flora similar to that of Wisconsin, it is interesting to note that of 151 species collected by Professor Herbert Osborn, only 33 species of that list were not taken in Wisconsin, while 108 were found there. In the Tennessee list we find 99 species occurring which have not been taken in Wisconsin, while 113 species are common to both states.

The Wisconsin list has extended the known range of a number of species which were supposed to be restricted to more southern areas. The southern fauna seems to extend up the Mississippi River Valley as far north as St. Paul, and apparently works northward through the deep valleys adjoining this valley. As an instance, *Deltocephalus vinnulus* Crumb, described from Tennessee a year ago, was found in central Wisconsin, while *Acinopterus acuminatus*, a typical southern form, was found well up in Wisconsin, although it is rarely found north of the Ohio River.

The northern portion of Wisconsin, which produces many Canadian forms of vegetation, and is dotted with many lakes and swamps, contains a rather limited number of peculiar species found only under such conditions.

The best collecting for the species of this group is in localities where the vegetation is in its most primitive condition—not having been disturbed by farm practices or any form of cultivation, and in the absence of forest or prairie fires. From these facts we can readily observe that usual farm practices of cultivation and rotation of crops, as well as the burning-over of infested land, are factors in checking the multiplication of these species and their resulting damage to crops.

Leaf hoppers are more or less restricted to certain food plants, although some species seem to have but slight preference. In order to carry on satisfactory economic controls it is necessary to know where and under what conditions these forms occur naturally, and to determine their habits, including egg deposition, the methods of feeding and the form in which the species hibernates.

In the collection of leaf hoppers some interesting points have been determined, including the fact that when the temperature is very high in midsummer at midday, these forms seem to retire to the base of the plant, and are collected with difficulty, but earlier or later in the day they may be found in abundance on the same forms of vegetation. It is, therefore, advisable in collecting in midday to take advantage of open woodlands, or such conditions where the vegetation affords a reasonable amount of protection from the sun. Cloudy days are always advantageous for general collecting for these reasons. Some species, however, always feed very close to the ground, and can, therefore, be taken only by intensive sweeping close to the base of the plant.

It is to be hoped that these interesting forms will be collected more generally in the several states, than they have in the past, and that our economic entomologists will realize more fully the extent of damage which is caused by the millions of tiny sucking individuals occurring frequently in a few acres of pasture.

This list of species is numbered according to the "Check List of Hemiptera," prepared by Mr. E. P. Van Duzee, and published by the New York Entomological Society, 1916. The writers desire to express their appreciation of the kindly assistance and suggestions of Professor Herbert Osborn, in the preparation of this list, and also for the privilege of comparing the specimens with Professor Osborn's valuable collection. We wish also to express our appreciation to Mr. Joseph Knull, Harrisburg, Pa., for assisting in the preparation of the drawings.

Family—CICADELLIDÆ (Latr.) 1825.

Subfamily—BYTHOSCOPINÆ (Dohrn.)

1762. **Agallia novella** (Say)—Generally distributed.
1764. **A. 4-punctata** (Prov.)—Common.
1767. **A. sanguinolenta** (Prov.)—Common.
1777. **Idiocerus nervatus** VD.
1778. **I. pallidus** Fh.
1779. **I. suturalis** Fh. A fairly common species.
1779a. **I. suturalis var lunaris** Ball.
1781. **I. alternatus** Fh.
1782. **I. verticis** (Say).
1795. **I. lachrymalis** Fh.

Idiocerus subnitens n. sp.

(Figs. 1, 2, 3.)

Resembling *I. lachrymalis* in shape, slightly smaller and shiny, with a distinct brown median transverse band. Length 6 mm.

Vertex broad and very short; longer next eye than at middle, anterior margin slightly produced. Pronotum two and one-half times as wide as long; humeral angles broadly rounded and posterior margin slightly excavated. Elytra rather long, greatly overlapping at apex and well rounded; venation strong. Face broad, front almost as broad as long, margins angled at antennæ, gradually and evenly narrowed to clypeus. Loræ long, outer margins slightly rounded. Antennal pits unusually deep.

Color: Vertex pale yellow; two round spots in pits, a broad band just beneath with a spot extending back next either eye, and two extending back and diverging on the margin, black. A transverse row of four rather large white spots include the antennæ. Front, upper half pale; lower portion, clypeus and inner portions of loræ, dark brown. Pronotum pale, irregularly marked with dark brown forming four rather distinct blotches, one in either humeral angle and one either side of middle on the disc. Scutellum yellow, basal angles, two round spots on disc and a median line between them dividing just back of middle and extending to apex, dark brown. Elytra dark brown, iridescent; inner margin of clavus, and a transverse band just back of clavus milky white, subhyaline, apex smoky hyaline. Beneath light brown.

Genitalia: Female last ventral segment almost twice as long as preceding; rather evenly rounded from base to produced apex. Pygofers broad and stout, much exceeded by ovipositor.

Described from one female specimen swept from poplar at Tomah, Wis., August 2, 1916. This mature specimen differed so considerably from any known species by several well marked characters that it was thought advisable to describe it specifically.

1797. **I. snowi** G. & B.
1800. **I. cratægi** VD.—One specimen St. Croix Falls, Aug. 16, 1916.
1801. **I. provancheri** VD.
1807. **Macropsis gleditschiæ** (O. & B.)—Madison, Milwaukee.
1808a. **M. virescens var graminea** (Fabr.).—Southern part of state.
1809. **M. viridis** (Fh.).
1810. **M. occidentalis** VD.—Southern part of state.
1815. **M. basalis** (VD.)—Southern area.
1818. **M. bifasciata** (VD.)—Southern.
1824. **Oncopsis variabilis** (Fh.).
1825. **O. sobrius** (Walk)—Southern points.
1828. **O. fitchi** VD.—Southwestern points.

1829. **O. pruni** (Prov.)—One spec., Pembine, June 21, 1913.
1831. **O. nigrinasi** (Fh.)One spec., St. Croix Falls, Aug. 15, 1916.
1832. **O. fagi** (Fh.)—Southern.
1833. **O. distinctus** (VD.)—Southern.

Subf. CICADELLINÆ VD.

1847. **Oncometopia lateralis** (Fabr.)—General.
1847a. **O. lateralis var. limbata** (Say)—St. Croix Falls, Aug. 16, 1916.
1854. **Cicadella hieroglyphica** (Say.)—Gay's Mills, June 29, 1916.
1855. **C. gothica** (Sign.)—Abundant throughout state.
1859. **Kolla bifida** (Say.)—Sparingly in western areas of state.
1863. **Helochara communis** Fh.—Generally distributed.
1864. **Graphocephala coccinea** (Forst).—Common.
1873. **Draeculacephala angulifera** (Walk.)
1874. **D. mollipes** (Say).—Common.
1875. **D. minor** (Walk).—Common.
1879. **D. noveboracensis** (Fh.)
1884. **Eucanthus acuminatus** (Fabr.)—St. Croix Falls, Aug. 15, 1916. In damp undergrowth.

Subf. GYPONINÆ.

1894. **Penthimia americana** Fh.—3 spec. Lk. Geneva, Grand Rapids, Tomah.
1896. **Gypona rugosa** Spangb.—3 specimens, Merrillan.
1897. **G. 8-lineata** (Say).—Generally distributed.
1898. **G. cana** Burm.
1904. **G. striata** Burm.—4 spec. Camp Douglass, Sturgeon Bay; Taylors Falls, Minn.
1910. **G. bipunctulata** Woodw.—One specimen, Colfax, Aug. 9, 1916.
1917. **G. pectoralis** Spangb.—2 spec., Blue River, Lk. Geneva.
1923. **G. scarlatina** Fh.—3 spec., Madison, Camp Douglas.

Subf. JASSINÆ.

1936. **Acucephalus albifrons** (Linn.)—Two spec., Monroe, July 25, 1916.
1940. **Xestocephalus pulicarius** VD.—General.
1941. **X. superbus** (Prov.)—Central and northern.
1943. **X. coronatus** O. & B.– 2 spec., Amery, Aug. 11, 1916; Woodruff, Sept. 8, 1916.
1956. **Parabolocratus major** Osb.—General.
1957. **P. flavidus** Sign.—Two specimens, Madison, July 9, 1916.
1972. **Mesamia nigridorsum** Ball.—One spec., Grand Rapids, Aug. 21, 1916.
1975. **M. vitellina** (Fh.)—A northern species.
1983. **Scaphoideus auronitens** Prov.—General.
1984. **S. jucundus** Uhl.—Northern.
1988. **S. scalaris** VD.—Fairly common.
1989. **S. lobatus** VD.—Three spec., Woodman, July 27, 1916; Marshfield, Aug. 20, 1916.

1990. **S. ochraceus** Osb.—Three spec., Woodman, July 27, 1916; Amery, Aug. 10, 1916.
1991. **S. productus** Osb.—Generally northern.
1994. **S. intricatus** Uhl.
1996. **S. immistus** (Say).—Common.
1996. **S. immistus var. minor** Osb.—Common.
2014. **Platymetopius acutus** (Say).
2014a. **P. acutus** var. **dubius** VD.—Sixteen specimens, Ladysmith, Aug. 9, 1916.
2017. **P. cuprescens** Osb.—Northern.
2019. **P. cinereus** O. & B.—Madison & Woodman (July, Aug.).
2020. **P. augustatus** Osb.—Two spec., Camp Douglas, Aug.1, 1916.
2023. **P. frontalis** VD.—Common at southern points.
2029. **P. magdalensis** Prov.
2033. **Deltocephalus bilineatus** G. & B.—Amery, Aug. 13, 1916; Marshfield, Aug. 20, 1916.

Deltocephalus luteocephalus n. sp.

(Figs. 19, 20, 21, 22.)

This beautiful species is readily distinguished by the ivory yellow head and orange red ocelli; elytra and general coloration resembling *D. bilineatus*. Length 3.5–4 mm.

Vertex convexly produced, pointed, twice as long in middle as next the eye, slightly wider than long. Pronotum equal to vertex in length, humeral angles evenly rounded to the almost truncate posterior margin. Elytra long and rather narrow, apex evenly rounded; nervures distinct. Face rather broad; front convex, evenly narrowed to the clypeus which is broader at apex than base. Antennal pits deep.

Color: Vertex white to ivory yellow; ocelli orange red and a median black suture on basal two thirds. Anterior margin of pronotum ivory white, darker posteriorly. Scutellum yellow. Face immaculate, ivory yellow, antennal pits black. Elytra smoky subhyaline; claval, discal and apical cells darker. Costal and apical cells darker brown distally. Nervures white margined with brown. Beneath pale.

Genitalia: *Female* last ventral segment rather long, broadly and slightly emarginate, with a shallow rounded notch at middle between two black spots. Pygofers beset with long brown hairs at apex. *Male* valve very short, broadly rounded. Plates large, convexly narrowed to bluntly rounded apices, each with a large brown spot near tip. Pygofers densely clothed with brown hairs.

A pair from Madison, (Lake Wingra), July 1, 1916.

2034. **D. imputans** O. & B.—Grand Rapids, Aug. 21, 1916.
2039. **D. inflatus** O. & B.—Tomah and Grand Rapids (Aug.).
2044. **D. reflexus** O. & B.—Grand Rapids and Taylors Falls, Minn., (Aug.)
2045. **D. pectinatus** O. & B.—One spec., Madison, July 9, 1916.

2048. **D. abbreviatus** O. & B.—Two spec., St. Croix Falls, Aug. 16, 1916; Grand Rapids, Aug. 21, 1916.
2049. **D. stylatus** Ball.—One spec., Grand Rapids, Aug. 21, 1916.
2051. **D. configuratus** Uhl.—One spec., Pembine, Sept., 4, 1916.
2053. **D. sayii** (Fh.)—Common. July and August.
2054. **D. missellus** Ball.—Common.
2055. **D. weedi** VD.—One specimen, Blue River, July 28, 1916.
2059. **D. compactus** O. & B.—Not common, generally distributed.

Deltocephalus nigriventer n. sp.

(Figs. 23, 24, 25, 26).

Resembles *D. compactus* in size and form, but with unique genitalia. 2.50–2.75 mm. long.

Vertex obtusely angled, two thirds as long as width between the eyes. Pronotum slightly longer than vertex, anterior margin strongly convex to humeral angles, truncated posteriorly. Elytra short and broad, exceeding the abdomen; venation indistinct. Face broad, convexly rounded to a quadrangular clypeus; loræ semi-circular.

Color: Two apical spots just anterior to a broad sinuate band, interrupted at middle, connecting the eyes, and ocelli, black. Pronotum milky gray, anterior half vaguely mottled with brown. Scutellum with basal angles and median stripe black. Elytra milky gray, sub-hyaline; clavus irregularly mottled with brown; a large spot each on discal cell, third anteapical cell and midway on costal margin, black. Nervures milky white. Face black with several pairs of pale lateral arcs. Clypeus with median black stripe forming a spot at apex; loræ margined with black. Venter black, segments pale margined.

Genitalia: *Female* last ventral segment twice as long as preceding, produced, broadly truncate, incised nearly to base; margins of incision almost overlapping, roundingly angled. Ovipositors and pygofers dull black, the latter beset with many short paler bristles posteriorly. *Male* valve scarcely longer than preceding segment, obtusely pointed. Plates large, broadly convex, tapering to rounded, upturned points; margin and dorsal surface with pale hairs.

Six females and two males from Merrillan, August 5, 1916, and one female from Tomah, August 2, 1916, were swept from small grasses. The female genitalia are decidedly unique for the genus.

2060. **D. vinnulus** Crumb.—Four specimens, Grand Rapids, Aug. 21, 1916. These specimens agree exactly with cotypes from Tennessee.
2062. **D. apicatus** Osb.—One specimen Merrillan Jt., Aug. 5, 1916.
2063. **D. inimicus** (Say)—Generally distributed.

Deltocephalus fumidus n. sp.

(Figs. 11, 12, 13, 14).

Uniform smoky brown iridescent, with black ocelli. Length 4.5 to 5 mm.

Vertex similar to **D. inimicus**, about as long as width between the eyes, flat. Pronotum twice as wide as long, and one-half longer than vertex, strongly convex anteriorly; humeral angles sloping sharply to truncate posterior margin. Elytra long, strongly curved on costal margin, rounded at apex. Front convex, triangular, evenly narrowed to the rectangular clypeus. Loræ small, narrow and distant from margin.

Color: Vertex pale, shading to smoky brown at apex; ocelli conspicuously black, encircled with white. Pronotum, scutellum and elytra vitreous pale brown. Nervures paler, narrowly margined with brown. Face smoky shading to lighter on clypeus and genae. Abdomen above black, beneath pale grey.

Genitalia: *Female* last ventral segment longer than preceding; posterior margin truncated and slightly sinuated and infuscated either side or middle. Ovipositor black, pygofers long and thickly clothed with dark hairs on apical third. *Male* valve short, triangular, inserted in the concavity of preceding segment; plates long, broad at base, and concavely narrowed to pointed apices. A single row of hairs on outer margin. Base of each plate with a median brown spot. Pygofers densely clothed with brown hairs.

One female and thirteen males at Woodman, July 27, 1916.

2071. **D. debilis** Uhl.—One specimen, Colfax, Aug. 9, 1916.
2075. **D. melsheimerii** Fh.—Common in northern localities.
2079. **D. affinis** G. & B.—Common.

Deltocephalus concinnus n. sp.

(Figs. 4, 5, 6).

Form and size of *D. affinis*, with two parallel brownish stripes on vertex, pronotum and scutellum. Length 3.25–3.50 mm.

Vertex flat, as long as wide, bluntly angled. Pronotum equaling vertex in length, strongly convex to the broadly rounded humeral angles, posterior margin truncate. Elytra rather long, just exceeding abdomen, tips broadly rounded and slightly flaring. Face about as broad as long, sutures of front and clypeus forming a straight line.

Color: Testaceous; ocelli black; vertex, pronotum and scutellum with two broad parallel brownish stripes; pronotum with an additional stripe behind either eye. Nervures white. Abdomen pale orange above. Venter yellow. Face dusky; a median line and traces of several pairs of arcs, dull yellow.

Genitalia: *Female* last ventral segment slightly longer than preceding; almost truncate with median brown spot. Pygofers robust; posterior two thirds with many pale hairs.

Two females collected at Ladysmith, August 9, 1916.

2081. **D. oculatus** O. & B.—General in northwestern localities.
2083. **D. sylvestris** O. & B.—Generally distributed.
2090. **D. osborni** VD.—Rather generally distributed in central and northern areas.
2097. **D. balli** VD.—Madison, July 21, 1916; Amery, Aug. 14, 1916.
2126. **Driotura gammaroides** (VD).—One spec., Merrillan, Aug. 3, 1916.
2131. **Euscelis exitiosus** (Uhl.)—Southern portion of state.
2132. **E. striolus** (Fall.)—Generally distributed.
2133. **E. parallelus** (VD.)—Generally distributed.
2134. **E. extrusus** (VD.)—Lake Geneva, June 21, 1916; Pine Lake, July 16, 1916.
2138. **E. uhleri** (Ball)—One spec., St. Croix Falls, Aug. 16, 1916.
2142. **E. arctostaphyli** (Ball)—1 spec., Madison, July 22, 1916.
2143. **E. humidus** (Osb.)—In bog at Ladysmith, Aug. 9, 1916.
2144. **E. striatulus** (Fall.)—Pembine, Trout Lk., Amery (Aug. and Sept., 1916).
2145. **E. vaccini** (VD.)—Pembine, Merrillan, Amery (Aug. and Sept., 1916).
2146. **E. instabilis** (VD.)—Trout Lake, Aug. 6, 1913; Ladysmith, Aug. 9, 1916.

Euscelis deceptus n. sp.

(Figs. 40, 41, 42).

Coloration and general appearance of *D. osborni*, but lacking the venation of *Deltocephalus* and definite markings. Dull testaceous. Length 5.5–6 mm.

Vertex short and broad, rounding to front, almost twice as long on middle as next the eye; two and one-half times as broad as long. Width of pronotum more than twice the length; lateral margins distinct, humeral angles broadly rounded to shallow emargination posteriorly. Elytra broad, subhyaline, exceeding the abdomen in length; apices well rounded. Front equal in length and breadth, well rounded to the quadrangular clypeus.

Color: Vertex testaceous, with an indistinct brown transverse band, sometimes interrupted in middle, on center of disk. Ocelli bright red. Pronotum dull testaceous, with a row of four to six very indistinct spots just behind anterior margin. Scutellum with two discal spots and apical angle brownish. Elytra a dirty yellow, with intermediate brown markings. Venation usually indistinct. Venter pale bordered with brown. Face pale testaceous, several pairs of arcs on front, sutures, and margins of loræ, brown.

Genitalia: *Female* last ventral segment, twice as long as preceding, broadly excavated with a black spot and a small tooth at the middle. Lateral margins of segment and ovipositor black. Pygofers bright yellow, posterior half evenly clothed with brown hairs. *Male* valve narrow, triangular, apex rounded; plates short and broad, convexly rounding to blunt apex with a marginal row of hairs. Discs of valve and plates with a brown spot.

Females collected: One each, Milwaukee, July 18, 1916; Madison, July 1, 1916, and July 21, 1916; Chicago, Ill., June 24, 1910. Males: One at Chicago, June 24, 1910, and one short-winged male from Fryeburg, Me., September 5, 1913.

2148. **E. elongatus** (Osb.)—Milwaukee, Madison, Pembine (July).
2156. **E. curtisii** (Fh.)—General.
2160. **Eutettix luridus** (VD.)—Eleven spec., Trout Lake, Sept. 7, 1916.
2161. **E. marmoratus** VD.—Four specimens, St. Croix Falls, Aug. 16, 1916.
2163. **E. subaeneus** (VD.)—One specimen from Madison referred to this species.
2179. **E. seminudus** (Say).
2180. **E. cintus** O. & B.—One spec., Grand Rapids, Aug. 21, 1916.
2181. **E. strobi** (Fh.)—One specimen, Milton Jct., Sept. 12, 1911.
2195. **Phlepsius majestus** O. & B.—One spec., Woodruff, Sept. 8, 1916.
2201. **Ph. decorus** O. & B.—Four spec., Grand Rapids, Aug. 21, 1916; Trout Lake, Sept. 7, 1916.
2204a. **Ph. cumulatus** var **arctostaphylae** Ball.—Abundant at Taylors Falls, Minn., just across the St. Croix river from St. Croix Falls, Wis., Aug. 16, 1916; from Partridge berry (**Michella repens**).
2221. **Ph. altus** O. & B.—One specimen, Woodman, July 27, 1916.
2223. **Ph. incisus** VD.—Three specimens, Blue River, July 28, 1916.

Phelpsius umbrosus n. sp.

(Figs. 15, 16, 17, 18).

A dark brown robust species resembling *P. incisus* in form and size. Head scarcely narrower than pronotum. Length 6–6.5 mm.

Vertex obtusely angled, almost twice as long in middle as next the eye; breadth three times the length. Pronotum very strongly convex, twice the length of vertex, and two and a half times as wide as long. Elytra broad, well rounded at tips. Face slightly longer than broad; frontal sutures straight to clypeus, which is broadest at apex; loræ broad, evenly rounded and approximating the margin.

Color: Vertex evenly irrorate, with pale spot at the base next each eye; ocelli pale. Pronotum evenly irrorate and punctulate. Elytra milky white, rather densely and evenly inscribed with dark brown. Face dark brown, evenly irrorate with testaceous.

Genitalia: *Female* last ventral segment twice the preceding in length; lateral angles produced and sharply rounded to an arcuate posterior margin incised at middle, forming two produced broadly rounded lobes, margined by a large semicircular brown spot extending half way to the base. *Male* valve almost equaling last ventral segment in length, slightly concave to an obtuse point. Plates long, evenly narrowed to small blunt points; each outer margin with a few stout bristles.

One female and two males, Grand Rapids, August 21, 1916.

2228. **Ph. irroratus** (Say)—Common.
2230. **Ph. collitus** Ball.—Amery and Tomah, Aug. 13, 1916.
2234. **Ph. lobatus** Osb.—Grand Rapids, Aug. 21, 1916; Taylors Falls, Aug. 16, 1916.
2236. **Ph. apertus** VD.—Two specimens, Trout Lake, Aug. 6, 1913; Pembine, Sept. 4, 1916.
2237. **Ph. fulvidorsum** (Fh.)—One spec., St. Croix Falls, Aug. 15, 1916.
2246. **Ph. solidaginis** (Walk.)—Common in western central areas.

Phelpsius bifidus n. sp.

(Figs. 7, 8, 9, 10).

Resembling *P. solidaginis* in general appearance, but smaller and with distinct genitalia. Length 6-6.5 mm.

Vertex sharp margined, slightly produced and upturned; disc concave, almost twice as long on middle as next the eye; width between the eyes two and one half times the length. Pronotum almost twice as long as vertex, humeral angles well rounded, disc with coarse punctures. Elytra broad, well rounded and flaring at the tips. Face almost as broad as long; front concave below margin, strongly narrowed from antennal pits to clypeus.

Color: Vertex pale, rather heavily irrorate with brown; a spot on upturned apex and one near each eye at either side of base, pale. Narrow anterior margin of pronotum pale, posteriorly dark with light punctures. Elytra milky white, sparsely irrorate except on discal cell and apex of clavus. Veins, a dark spot on base of inner apical cell and four spots on costa, each one at termination of apical costal veins, brown. Face heavily irrorate with brown above, causing it to appear dark in color. Below showing traces of a median line and five pairs of pale arcs. Beneath dark brown, differing greatly from other species.

Genitalia: *Female* last ventral segment twice as long as preceding, strongly produced, angularly rounded to a deep "V" shaped incision, extending more than half way to base. Incision margined with brown. *Male* valve as long as preceding segment, obtusely triangular, plates three times as long as valve, broad and convex at base, then narrowing concavely to blunt points. Margins only beset with short heavy bristles and marked with black points.

Four specimens, two females from Trout Lake, August 6, 1913, and September 7, 1916, and two males from Amery, August 13, 1916, and Woodruff, September 8, 1916.

2247. **Ph. ramosus** (Baker).
2249. **Acinopterus acuminatus** VD.—One specimen from brake ferns(?) at Camp Douglas, Aug. 1, 1916.
2262. **Thamnotettix cockerelli** Ball.—One specimen, Woodruff in extreme northern portion of state, Sept. 8, 1916.
2263. **Th. morsei** Osb.—Three specimens, Trout Lake in northern part of state, Sept. 7, 1916.
2265. **Th. clitellarius** (Say).—Generally distributed.
2286. **Th. atridrosum** VD.—Six specimens from northern localities.
2292. **Th. chlamidatus** (Prov.)—Pembine, July 26, 1916.
2305. **Th. melanogaster** (Prov.)—Generally distributed.

Thamnotettix stramineus n. sp.

(Figs. 27, 28, 29, 30, 31.)

Bright shining straw yellow with two narrow black dashes on margin of vertex. Length 6.5–7 mm.

Vertex very bluntly angled, one-half as long as broad, and half longer in middle than next the eye. Pronotum one-half longer than the vertex, with humeral angles broadly rounded, posterior margin nearly truncate. Elytra one-third longer than the abdomen, clavus extending to tip of abdomen. Face broad, roundingly convex and suddenly narrowed to the quadrangular clypeus.

Color: Vertex yellow, margin with two short transverse dashes and a point on either side, black. Anterior margin of pronotum with yellow band, remainder shiny greenish yellow or darker, scutellum dull yellow. Elytra greenish yellow, subhyaline, shiny; nervures yellow. Beneath yellow in female; black margined with yellow in male; legs yellow. Face yellow, lateral sutures and antennal pits sometimes black.

Genitalia: *Female* last ventral segment as long as preceding, strongly produced with broad, shallow posterior emargination; a black raised disk on each side, embossed with deep converging striæ. These disks joined by a brown or black band in dumb-bell fashion. Pygofers pale with long yellow hairs on posterior two-thirds. Ovipositor slightly darker. *Male* valve large and strongly convex, apex broadly rounded; plates as long as valve, divergent, convexly produced to a sharp black point; pygofers long, black at extreme tips and bearing an unusual number of long white hairs.

Specimens collected as follows: Ladysmith, Aug. 9, 1916, seven females and four males; Amery, Aug. 13, 1916, two females; Madison, July 22, 1916, one female and two males; Blair, Aug. 8, 1916, one female; Marshfield, Aug. 20, 1916, six females.

2306. **Th. ciliatus** Osb.—At Madison on sedges, Aug. 30, 1916.
2307. **Th. decipiens** Prov.—In extreme north of state on sedges.
2308. **Th. smithi** VD.—General.
2312. **Th. fitchii** VD.—Common.
2314. **Th. nigrifrons** (Forbes).—Common in southern part of state.
2318. **Th. inornatus** VD.—Northern localities on wild rye.

Thamnotettix mellus n. sp.

(Figs. 46, 47, 48, 49.)

A small, shiny, yellow, unmarked species, 4.5–5 mm. in length.

Vertex short, obtusely angled, less than one-half longer on middle than next the eye, and nearly twice as long as broad. Pronotum nearly twice as long as vertex, humeral angles broadly rounded, and posterior margin nearly truncate. Elytra relatively long, much exceeding abdomen. Nervures distinct. Face short, broad and suddenly narrowed to the clypeus which is broadened and well rounded at the apex.

Genitalia: *Female* last ventral segment long, lateral angles broadly concave emargination enclosed by a lunular brown area. Ovipositor and pygofers long, the latter with many long pale hairs on posterior two-thirds. *Male* valve very short, evenly rounded, one-half length of previous segment; plates long triangular, gradually tapered to blunt points, outer margin clothed with pale hairs.

Color: Vertex and face smoky yellow, unmarked. Anterior margin of pronotum and scutellum, pale yellow; posterior margin darker. Elytra dull pale yellow, clavus washed with brighter yellow. Venter and legs yellow; tarsal claws black.

A pair from Trout Lake, Vilas Co., August 6, 1913.

2319. **Th. placidus** Osb.—At northern points.
2320. **Th. cyperaceus** Osb.—General on sedges.

Thamnotettix vittipennis n. sp.

(Figs. 36, 37, 38, 39.)

Resembling *Th. cyperaceus* in general appearance. Vertex more rounded and with black marginal line as in *Th. smithi*. Length 5.5–6 mm.

Vertex one-half longer on middle than next the eye, evenly rounded, half as long as width between the eyes. Front evenly rounded to clypeus which is widened and almost truncate at apex. Pronotum about one-half longer than vertex, slightly emarginate behind; humeral angles broadly rounded. Elytral nervures distinct.

Color: Vertex with broad tawny band covering disc and extending to eyes; posterior central portion pale with a median suture; ocelli red; stripe on margin connecting eyes black. Face light, sutural lines of front black. Pronotum tawny to testaceous, anterior margin lighter.

Elytra tawny, subhyaline, nervures white margined with brown, appearing striped. An indistinct brown band extends from humeral angles to the tips of elytra, interrupted by the pale nervures. Venter black, margined with yellow; ovipositor and tips of male plates black.

Genitalia: *Female* last ventral segment as long as preceding, longitudinally striated; posterior border slightly emarginate and narrowly notched either side of middle; pygofers long beset with long brownish bristles. *Male* valve broad, long, apex roundingly angled. Plates short, broadly and convexly rounded, posterior half diverging to a black rugose blunt point. Posterior half beset with many long white bristles.

Four specimens, a pair from Trout Lake, Sept. 7, 1916, and two males from Ladysmith, Aug. 9, 1916, were swept from sedges in low swampy ground.

2324. **Chlorotettix unicolor** (Fh.)—Common and generally distributed.
2326. **Ch. spatulatus** O. & B.—In northwestern localities.
2327. **Ch. tergatus** (Fh.)—Throughout the State.
2331. **Ch. galbanatus** VD.—At northwestern points.

Chlorotettex borealis n. sp.

(Figs. 32, 33, 34, 35.)

Resembling *C. vividus* in shape, but slightly smaller and with distinct genitalia. Length 5 mm. Much smaller than any other known northern species.

Vertex obtusely angled, slightly more than one-half longer on the middle than next the eye, twice as broad as long. Anterior margin of pronotum strongly convex; posterior margin slightly concave; lateral angles broadly rounded. Elytra smoky hyaline.

Color: Resembling **C. vividus** in color, more of grass green than found in most species of the genus. Last ventral segment of female with a dark median stripe from the apex of the incision to the base of the segment. Ovipositor dark. Tibia and tarsi of front legs brownish.

Genitalia: *Female* last ventral segment twice as long as preceding, lateral angles well rounded. A rather broad median notch extending half way to the base; sides convexly angled posteriorly. *Male* valve twice as long, triangular with rounded apex. Plates rather long, convexly rounded to rather blunt tips. Hairs mostly on margin and dorsal surface.

A pair were swept from grass in a clearing at Trout Lake, Sept. 7, 1916.

2336. **Ch. lusorius** O. & B.—At central and northern points.
2340. **Jassus olitorius** Say.—Two specimens, Woodman, July 27, 1916; Tomah, Aug. 2, 1916.
2343. **Neocoelidia tumidifrons** G. & B.—One spec., Tomah, Aug. 2, 1916.

2356a. **Cicadula punctifrons** var. **repleta** Fieb.—Two specimens from Augusta, Aug. 4, 1916.
2358. **C. variata** (Fall.)—Common.
2359. **C. lepida** VD.—Common.
2362. **C. 6-notata** (Fall.)—Common.
2368. **C. slossoni** VD.—Merrillan & Tomah, Aug. 2, 1916.
2370. **Balclutha punctatus** (Thunbg.)—Common.
2371. **B. osborni** VD.—General.
2373. **B. impictus** (VD.)—General.
2377. **Eugnathodus abdominalis** (VD.)
2380. **Alebra albostriella** (Fall.)—Southern points.
2384. **Dicraneura cruentata** Gill.—St. Croix Falls, Aug. 16, 1916.
2386. **D. mali** (Prov.)—Common.
2387. **D. abnormis** Walsh.—Two specimens, Blue River, July 28, 1916.
2393. **D. fieberi** (Loew.)—Common.
2395. **Empoasca smaragdula** (Fall.)—Three spec., Madison, Merrillan and Gay's Mills.
2396. **E. aureoviridis** (Uhl.)—Three spec., Madison, June 10, 1912; Greenwood, Aug. 19, 1916.
2397. **E. unicolor** Gill.—One specimen, La Crosse, Aug. 7, 1916.
2398. **E. obtusa** Walsh.
2401. **E. atrolabes** Gill.
2403. **E. denticula** Gill.—One spec., Pembine, July 26, 1910.
2416. **E. snowi** Gill.—Southern.
2421. **E. mali** (LeB.)—Common.
2422. **E. flavescens** (Fabr.)
2423. **E. viridescens** Walsh.—One spec., Amery, Aug. 11, 1916.
2424. **E. birdii** Goding—Three spec., Marshfield, Aug. 20, 1916; Amery, Aug. 16, 1916.
2428. **Typhlocyba nigra** (Osb.)—One spec., Amery, Aug. 14, 1916.
2429. **T. flavoscuta** (Gill.)—Common at Marshfield, Aug. 20, 1916, on ferns in dark woods. Also at Greenwood and Amery.
2430. **Empoa querci** Fh.—Common at Madison.
2430a. **E. querci** var. **bifasciata** (G. & B.)—Common.

Empoa aureotecta n. sp.

(Figs. 43, 44, 45).

Size and form of *E. querci;* basal two thirds of elytra uniform orange yellow without pattern. Length 3.75 to 4 mm.

Head produced, scarcely angled, almost a third longer on the middle than next the eye. Pronotum twice as long as the vertex. Elytra rather long, nervures indistinct.

Color: Vertex pronotum and scutellum bright yellow unmarked. Elytra uniform orange yellow from base to tip of clavus, whitish hyaline beyond, apex faintly smoky. Face, legs and venter pale yellow. Pygofers and ovipositor bright yellow, the apex of the latter, black.

Genitalia: *Female* last ventral segment twice as long as preceding, much produced, gradually rounding from lateral angles to a keeled, blunt apex. Pygofers stout, a row of short hairs either side of ovipositor.

Three female specimens swept from oak at Madison, July 9, 1916.

2434. **E. commissuralis** (Stal.)
2435. **E. tenerrima** (H. S.)—One spec., Bayfield (in extreme north), Sept. 10, 1916.
2437. **E. rosae** (Linn.)—Generally distributed.
2440. **Erythroneura trifasciata** (Say)—Generally distributed.
2441. **E. tricincta** Fh.—Madison and Lk. Geneva.
2443. **E. hartii** (Gill.)—Four specimens from Taylor's Falls, Aug. 16, 1916.
2445. **E. comes** (Say).—Common.
2445a. **E. comes** var. **vitifex** Fh.
2445b. **E. comes** var. **ziczac** Walsh.
2445c. **E. comes** var. **vitis** (Harr.)—Common.
2445d. **E. comes** var. **basilaris** (Say)—Amery, Aug. 11, 1916.
2445f. **E. comes** var. **rubra** Gill.
2445g. **E. comes** var. **maculata** Gill.—Madison.
2446. **E. illinoiensis** (Gill.)—Baraboo and Marshfield.
2447. **E. obliqua** (Say).
2447b. **E. obliqua** var. **noevus** (Gill.)—Lk. Geneva and Madison, June 21, 1916.
2447c. **E. obliqua** var. **fumida** (Gill.)--St. Croix Falls, Aug. 15, 1916.
2448. **E. vulnerata** Fh.
2448a. **E. vulnerata** var. **niger** (Gill.)—Amery, Aug. 11, 1916.

A total of 206 species and varieties, including 13 new species, are listed above. Additional species common to Iowa and Illinois should be found by collecting in the southwestern counties of Wisconsin near the Mississippi river.

EXPLANATION OF FIGURES.

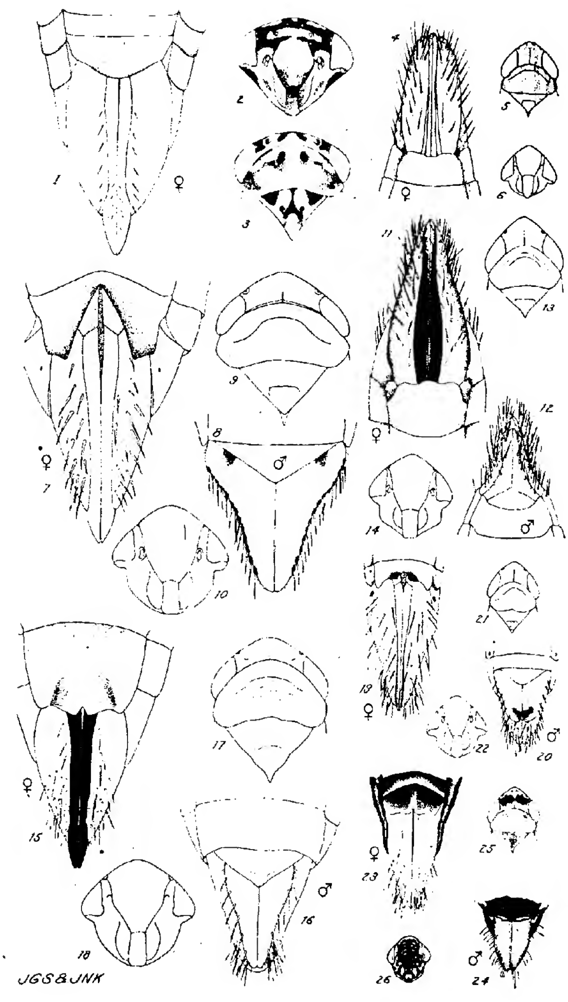
The figures of the vertex and face of species illustrated have been drawn to the same scale, while the genitalia have been drawn to the same scale, although more highly magnified.

PLATE VIII.

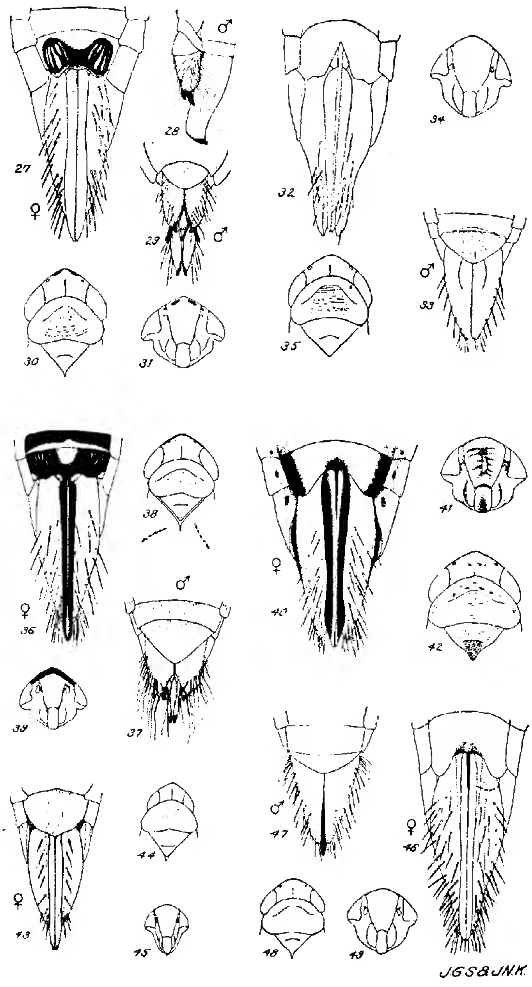
Idiocerus subnitens............Figs. 1, 2 and 3.
Deltocephalus luteocephalus....Figs. 19, 20, 21 and 22.
Deltocephalus nigriventer......Figs. 23, 24, 25 and 26.
Deltocephalus fumidus........Figs. 11, 12, 13 and 14.
Deltocephalus concinnus.......Figs. 4, 5 and 6.
Euscelis deceptus............Figs. 40, 41 and 42.
Phlepsius umbrosus..........Figs. 15, 16, 17 and 18.
Phlepsius bifidus.............Figs. 7, 8, 9 and 10.

PLATE IX.

Thamnotettix stramineus......Figs. 27, 28, 29, 30 and 31.
Thamnotettix mellus..........Figs. 46, 47, 48 and 49.
Thamnotettix vittipennis.......Figs. 36, 37, 38 and 39.
Chlorotettix borealis...........Figs. 32, 33, 34 and 35.
Empoa aureotecta.............Figs. 43, 44 and 45.



J. G. Sanders and D. M. DeLong.



J. G. Sanders and D. M. DeLong.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

New York Meeting.

The Eleventh Annual Meeting of the Entomological Society of America was called to order by First Vice-President E. P. Felt, in Room 411 of Teachers' College, Columbia University, New York City, at 2 P. M., December 26, 1916. After alluding to the death of the Society's President, F. M. Webster, which occurred on January 3, 1916, Dr. Felt appointed the usual committees, as follows:

Auditing—C. W. JOHNSON, WM. A. RILEY.

Resolutions—P. P. CALVERT, JAS. S. HINE.

Nominations—HENRY SKINNER, A. P. MORSE, J. C. BRADLEY.

The following papers were then read:

Life-histories and Habits of Gerridæ.......J. R. DE LA TORRE BUENO
Notes on the Habits and Immature Stages of Cyrtidæ...J. L. KING
Distribution of the Ohio Broods of Periodical Cicada with Reference to soil..H. A. GOSSARD
Insect Collecting in Cameroon, West Africa........REV. A. I. GOOD
Recent Observations and Theories Concerning the Origin of Social Habits among Vespidæ......................DR. J. BECQUAERT
The Phyletic Value of Ontogenetic Characters in the Elateridæ, J. A. HYSLOP
Biological Notes on Miris dolobrata...............HERBERT OSBORN
The Malpighian Vessels of the Alder Flea-beetle, WILLIAM COLCORD WOODS

At 5:15 the Society adjourned until the next morning, about 90 members having been in attendance.

December 27, 1916. The morning session was called to order at 9:30 by A. P. Morse, in the temporary absence of the First Vice-President. The following papers were read:

Some Recent Advances in Mosquito Work in New Jersey, THOS. J. HEADLEE
Studies on Coccobacillus acridiorum d'Herelle, and on Certain Intestinal Organisms of Locusts, E. MELVILLE DU PORTE AND J. VANDERLECK
Studies of Hypoderma lineatum and bovis.......SEYMOUR HADWEN

The time having arrived for the annual business session, the Executive Committee presented the reports of the Secretary, the Treasurer, the Managing Editor of the ANNALS, and of the Thomas Say Foundation, as follows:

REPORT OF THE SECRETARY.

The following members have been elected since the last annual meeting:

On July 17, 1916:

Frederick McMahon Gaige
Walter Allen Price
Shirley Lowell Mason
Lewis G. Gentner

On August 20, 1916:

Gonzalo Martinez Fortun
Ernest Melville Du Porte
Walter Norton Hess
Emerson Liscum Diven

On December 26, 1916:

H. B. Parks
Maurice E. Hays
C. W. Collins
Ray T. Webber
Chester Ittner Bliss
Rudolf William Glaser
Albert I. Good
Howard L. Clark
Frank R. Cole
Ralph Robinson Parker
Dettmar Wentworth Jones
Edward Riley King
Everett Elmer Wehr
Paul Hugo Isidor Kahl
Kirby Lee Cockerham
W. B. Williams
Seymour Hadwen
Herbert B. Hungerford
Christian E. Olsen
Phares H. Hertzog
William Bernard Donohue
Wallace Larkin Chandler
George Felix Arnold
Max Kisliuk
J. A. Corcoran

Total, 33.

The following members have resigned:

H. H. Brehme
Geo. Franck
W. A. Hooker
R. N. Wilson

Total, 4.

The following have died:

Francis Marion Webster, *President*
A. J. Cook
J. B. Williams
Ignaz Matausch
R. M. Moore

Total, 5.

Dropped for non-payment of dues, 11 members. Net gain, 14.

No Fellows or Honorary Fellows were elected in the year.

On December 14, 1916, the total membership of the Society was 578. Some idea of the interest of the members may be gained from the following figures regarding the payment of dues.

Disregarding for the moment the foreign members, life members, and honorary fellows, there were 10 members who were paid in advance at least for 1917; 414 were paid up for 1916; 54 were paid up for 1915; while 37 were owing for more than two years. These last are liable to suspension, but it costs the Society nothing to carry them, as they do not receive the ANNALS while in arrears, and the Secretary is endeavoring to revive their interest.

The year just closing has been a trying one for many of our foreign members, and yet their interest has been manifested in a gratifying manner. Out of 54 classed as foreign members (and in this classification the Secretary has rather arbitrarily included Cuba, Porto Rico, and Hawaii with continental North America, and not as foreign territory), the number who have paid dues during the year is just one-half, or 27. Several of these are in the war, and one sent his communication from the trenches. Regarding the other foreign members, obvi-

ously our wisest policy is to continue to carry them on the books until peace returns and they have an opportunity to resume the payment of dues. We all hope that they will then rejoin us in active membership.

The membership on December 14, 1916, was in the following classes:

Honorary Fellows	7
Fellows	47
Life Members	4
Regular Members	520
Total	578

Add 33 new members just voted in and our present membership is raised to 611.

TREASURER'S REPORT.

RECEIVED:

Balance last Treasurer's Report (ANNALS, March, 1916, p. 108) $110.36, less $12 outstanding check for clerical work for retiring Treasurer	$ 98.36	
Dues from members	930.44	
From Herbert Osborn, Managing Editor	354.33	
Interest on permanent Funds, January and July, 1916	10.29	
Interest on current balance	3.88	
Exchange	.26	
Total	$1,397.56	

PAID OUT:

Printing five numbers of ANNALS	$1,141.65	
Engraving for ANNALS	30.40	
To Herbert Osborn, for subscriptions	9.00	
Refunded to N. K. Jardine	3.33	
Thomas Say Foundation, preliminary expenses	40.00	
Printing for Secretary's office	30.00	
Stamped envelopes	39.08	
Clerical assistance	41.00	
Badges for annual meeting	11.00	
Express and stationery	2.99	
Interest on permanent funds, redeposited	10.29	
Balance on hand, December 14, 1916	38.82	
Total		$1,397.56

CONDITION OF PERMANENT FUNDS.

On deposit in Cleveland Trust Co., January 1, 1916:		
Four life memberships	$200.00	
Samuel Hubbard Scudder Fund	35.00	
Accumulated Interest	17.19	
Total		$252.19
Interest added to deposit:		
January 1, 1916	$ 5.15	
July 1, 1916	5.14	
Total		10.29
Total on Deposit December 14, 1916		$262.48

In accordance with previous action of the Executive Committee, enough of the accumulated interest will be added to the Samuel Hubbard Scudder Fund to bring it up to Fifty Dollars; this leaves the remainder of the interest, which may be drawn for running expenses of the Society. at $12.48.

REPORT OF THE MANAGING EDITOR OF THE ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

It has been possible during the present year to slightly increase the size of the volume as compared with the preceding year and the income which seems to be assured for the coming year will enable us to maintain the JOURNAL on the present basis.

The receipts and expenditures may be summarized as follows:

RECEIPTS.

Subscription account	$234.50
Sale of back numbers	150.32
Sale of reprints	34.80
Total Receipts	$419.62

DISBURSEMENTS.

Stamps, post office charges	$ 27.90
Stenographic help and labor	26.50
Engraving	10.89
Balance to Treasurer	354.33
Total Disbursements	$419.62

The appeal made to the members in regard to filling out their back sets seems to have been effective in a number of cases, as a larger number of back numbers were sold during the past year than in either of the two preceding years. We desire to express our appreciation for this assistance and especially for the securing of Library subscriptions which are ordinarily to be considered as continuations which will be of advantage to the publication in the future.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

REPORT OF THE THOMAS SAY FOUNDATION.

Of the six members of the Foundation appointed at the last annual meeting, Dr. Calvert resigned, and the Executive Committee by mail ballot, appointed J. M. Aldrich as editor, leaving the Foundation temporarily with only five members.

A meeting of the Foundation was called and convened at West LaFayette, Indiana, on September 11 and 12, 1916, at which were present A. D. MacGillivray, E. B. Williamson and J. M. Aldrich, a majority of the members. At this meeting J. M. Aldrich proposed that the Foundation print as its first volume his completed manuscript on "Sarcophaga and Allies in North America." On calculating the probable expense, the members believed that they were justified in going forward, and accepted the work as the first volume of the Foundation. Specifications were drawn up and bids obtained, and a contract let to the Murphey-Bivins Co., LaFayette, Indiana.

Arrangements were also made for the circulation of another appeal for ten-dollar advance subscriptions in the same envelope with the announcement of the coming meeting of the Entomological Society of America.

After the meeting, the printing of the book was completed according to contract, and subscribers have already received their copies.

A balance of $40.88 in the appropriation for preliminary expenses (ANNALS, March, 1916, p. 112) was drawn upon as follows:

Medallion of Say for frontispiece	$6.50
Printing appeal for subscriptions	6.50
Engraving 16 plates at $1.60	25.60
Greek characters and composition	1.40
Total	$40.00

The cost of printing an edition of 1000 and binding 200 is in all $456.00 in addition to the items mentioned above. This amount is due January 1. At the time of writing the funds in hand are somewhat over $300; the balance is arranged for temporarily, but will soon be made up from sales.

Respectfully submitted,

J. M. ALDRICH, *Editor.*

The Auditing Committee submitted the following report, which was on motion accepted:

"We have examined the accounts of J. M. Aldrich, Secretary and Treasurer, for the year ending December 14, 1916, and the accounts of Herbert Osborn, Managing Editor of the ANNALS, for the year ending December 1, 1916, compared the vouchers, and find them correct.

(Signed) CHAS. W. JOHNSON,
WM. A. RILEY,
Auditing Committee."

The Executive Committee further reported that they had appointed the following members of the Editorial Board of the ANNALS to take the place of Messrs. Kellogg, Howard and Wheeler, whose terms have expired:

T. D. A. COCKERELL, WM. A. RILEY, L. O. HOWARD.

Also that they had appointed the following members on the Thomas Say Foundation, in pursuance of the Constitutional provisions adopted since the last appointments a year ago:

Members for two years—NATHAN BANKS, A. D. MACGILLIVRAY.

Members for one year—MORGAN HEBARD, E. B. WILLIAMSON.

Editor—J. M. ALDRICH.

Treasurer—E. D. BALL.

The Committee further reported, in the case of a certain member whose commercial efforts were open to criticism, and were apparently aided by his advertising himself as a member of this Society, that the Secretary is instructed to request him to resign; if he does not do so, the Secretary is instructed to drop his name from the books and publish a statement of the facts in the ANNALS.

The Committee on Resolutions submitted the following report, which was on motion adopted:

"The Entomological Society of America desires to record its hearty appreciation of the action of the authorities of Columbia University and of Teachers' College in placing rooms and other facilities at the disposal of the Society for the purposes of the Annual Meeting.

The Society also thankfully acknowledges the courtesies it has received and is about to experience this evening from the American Museum of Natural History and from the Entomological Societies of New York and Brooklyn. (Signed) PHILIP P. CALVERT,
JAS. S. HINE,
Committee."

The Nominating Committee submitted the following report:

"The Nominating Committee nominate the following officers for the coming year:

President—LAWRENCE BRUNER.

First Vice-President—E. M. WALKER.

Second Vice-President—H. C. FALL.

Secretary-Treasurer—J. M. ALDRICH.

Executive Committee—E. B. WILLIAMSON, A. D. HOPKINS, W. J. HOLLAND, E. D. BALL, C. W. JOHNSON.

Respectfully submitted,
(Signed), HENRY SKINNER,
A. P. MORSE,
J. CHESTER BRADLEY,
Committee."

On motion, the Secretary was instructed to cast the ballot of the Society for the officers; which being done, they were duly declared elected.

Dr. Skinner moved that in the opinion of the Society, in taxonomic work a single type should be used, and that we recommend this policy. The motion being seconded, Professor Riley moved to refer it to the Committee on Nomenclature with instructions to report, which was carried.

Professor Riley moved that it be the sense of the meeting that papers should be limited to ten minutes. Dr. Headlee moved to leave the matter to the Secretary, which was carried.

No further business appearing, at 12 M. the Society adjourned until afternoon.

December 27, 1916, 2 P. M. The Society was called to order by Vice-President Felt, and the program of papers was continued, as follows:

Some Modifications in the Legs of Insects, A. PETERSON AND A. D. MACGILLIVRAY

The Morphology of a Lepidopterous Head............EDNA MOSHER

The Genus Erax in North America.....................JAS. S. HINE

Entomology at the National Museum*...........T. D. A. COCKERELL

*Published in *Entomological News*, xxviii, p. 55, Feb., 1917.

Following Professor Cockerell's paper, it was moved and carried that a committee be appointed by the Executive Committee to promote the adequate development of the insect collections of the National Museum. Vice-President Felt stated that the committee would be announced at the evening session. The reading of papers continued, as follows:

Entomological Charts.............................Z. P. METCALF
A Guide to a Laboratory Study of the Scale Insects....R. A. COOLEY
The Food of Drosophila.........................J. P. BAUMBERGER
Observations on Grylloblatta campodeiformis.....C. GORDON HEWITT
Sarcophaga haemorrhoidalis Larvæ as Parasites of the Human Intestine.......................................L. HASEMAN

(On account of the absence of the authors, the last two were read by the Vice-President and the Secretary.)

At 5:10 P. M., the Society adjourned until evening.

At 6 P. M., in company with the Association of Economic Entomologists, in the rooms of the American Museum of Natural History, the society was entertained by the New York and Brooklyn Entomological Societies at a buffet supper; and at 7:30 P. M. reassembled in one of the lecture rooms of the Museum, where the Annual Address of the Entomological Society of America was delivered by Professor T. D. A. Cockerell, on the subject, "Fossil Insects."

On calling the meeting to order, Vice-President Felt announced that the Executive Committee had selected the following committee to promote the adequate development of the insect collections of the National Museum:

T. D. A. COCKERELL, HERBERT OSBORN, H. T. FERNALD, WM. M. WHEELER, JAS. G. NEEDHAM.

The program of the Annual Meeting having been completed, the Society adjourned *sine die*.

(Signed) J. M. ALDRICH,
Secretary-Treasurer.

NOTICE.

In accordance with instructions given me by the Executive Committee at the Annual Meeting in New York City, on December 27, 1916, I have dropped the name of James Sinclair from the list of members of the Entomological Society of America.

J. M. ALDRICH, *Secretary-Treasurer.*

West Lafayette, Ind., Feb. 9, 1917.